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Incremental Validity of Enhanced Computer Administered Testing (ECAT)

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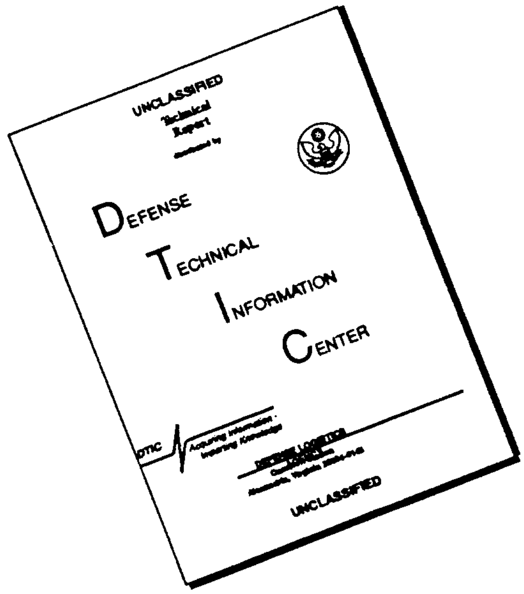

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13. ABSTRACT *(Maximum 200 words)*

The Enhanced Computer Administered Testing (ECAT) project was a joint-service effort to estimate the potential increase in validity that could be obtained by adding new computerized tests to the current Armed Services Vocational Aptitude Battery (ASVAB). Over 10,000 recruits were tested with nine experimental computerized tests of working memory, spatial ability, and psychomotor ability. Data on the examinees' subsequent technical school performance for three Army, two Air force, and 13 Navy schools were collected, measuring laboratory, shop, training simulator and other tests of hands-on performance as well as school grades. The corrected multiple correlation of all ten ASVAB tests with each criterion was compared with the multiple correlation from the ECAT added to the predictor set. Results showed very large increases in validity (exceeding .10) for prediction of Air Force and Navy Air Traffic Control performance using Working Memory and Spatial tests, and even larger increases for the Army's 11H Heavy Antiarmor Weapons Crewman time-on-target averages, using psychomotor and spatial tests. Other schools, where ASVAB's validity was already high, did not show higher validity when ECAT tests were added. Averaged over all schools, validity for predicting schools' grades increased two percent, and validity for predicting performance increased nearly six percent.

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Foreword

The Navy Personnel Research and Development Center is the lead laboratory for the Enhanced Computerized Aptitude Testing (ECAT) project. The purpose of the project is to assess the cost/benefits of adding new aptitude tests to the Armed Services Vocational Aptitude Battery (ASVAB). This report presents results of a large-sample study that shows the incremental validity of adding new tests to the ASVAB for predicting both written and practical measures of technical school performance.

This effort was sponsored by the Navy Chief of Personnel (PERS-234). Portions of the work were funded under three related projects: the New Measures of Intelligence project (Work Unit 0603707N.L1770.MP105), the CAT research and development project (Work Unit 0604703N.R1822.MH001), and the Joint Services CAT-ASVAB project (Work Unit 93WRE5083). Results are intended for use by BUPERS, the joint services Manpower Accession Policy Steering Committee, and the research community.

KATHLEEN E. MORENO
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Summary

Background

All applicants for military enlistment are selected and classified by using the scores on the Armed Services Vocational Aptitude Battery (ASVAB). Previous studies by the Army, Air Force, and Navy suggested that the ASVAB might have increased validity if new tests were added or substituted for the existing ones, particularly computerized tests of abilities not easily measured by paper-and-pencil tests. The utility of a 3% increase in validity had been estimated to be in the tens of millions of dollars from the resulting improvement in selection and classification. Accordingly, the military services, under the guidance of DOD, undertook a large-scale validation of the most promising experimental tests developed by the services' personnel laboratories. This joint-service battery of nine experimental tests was called the Enhanced Computer Administered Testing (ECAT) battery.

Objective

The ECAT project was designed to estimate how much validity gain could be obtained from adding the ECAT tests to the ASVAB, determine which tests were most promising, and determine in what military occupational specialities the gains were the largest.

Approach

Over 10,000 recruits scheduled for training in 3 Army schools, 2 Air Force schools, or 13 Navy schools were administered the ECAT battery. Seventy-seven criteria for training performance were collected among the 18 schools, including many hands-on performance measures. The validity of the ASVAB tests in a multiple regression equation was compared with the validity of the combined ECAT and ASVAB battery. Four kinds of analyses were done for incremental validity in terms of (1) general ability, (2) ability factors, (3) individual tests, and (4) unit-weighted selector composites.

Results

Working memory and spatial ability tests produced large increases in validity for predicting Air Traffic Control training performance in two Air Force samples and one Navy Sample. Psychomotor tracking tests and spatial ability tests greatly increased prediction of Heavy Antiarmor Weapons firing accuracy.

Using all ECAT tests, six of 13 Navy schools showed significant increase in validity. Averaged over all schools, the prediction of hands-on performance increased over 5%, while the prediction of School Grades improved only 2%.

About 75% of the incremental validity of ECAT can be attained by using just three of the nine tests: Two-Hand Tracking, Mental Counters, and Assembling Objects, each of which represents a different ability factor.

Conclusions

Many ECAT tests have substantial simple validities for predicting school performance. In some military training courses, the ASVAB's prediction of school practical performance can be substantially improved by using ECAT tests in optimally-weighted composites. Validity increases are greatest (averaging 5.7%) when laboratory or simulator performance criteria are used, rather than school grades (averaging 1.7%). Increases for some schools are much larger than this, while other schools have no significant validity improvement. Factor scores are more than 98% as valid as individual tests in multiple regression, but relying on "***g***" alone reduces validity by as much as 8.9% on the average. ECAT tests can be used to broaden the estimate of general mental ability, or "***g***" produced by the ASVAB. This enhanced "***g***" has validity increments for predicting practical performance criteria which are nearly as large as the validity increments from using all tests in multiple regression. Existing selector composites can be improved by adding ASVAB tests to them. In many cases, the validity improvements from doing so exceed those from adding an ECAT test with unit weights.

Recommendations

1. Consideration should be given toward the eventual incorporation into ASVAB of a Spatial Ability measure, such as Assembling Objects.
2. If CAT-ASVAB is universally implemented, then consideration should be given toward including computerized tests of working memory, such as Mental Counters.
3. The Mental Counters test should be considered for supplementary administration to potential students in the Air Force and Navy Air Traffic Control schools.
4. The Two-Hand Tracking test should be considered for supplementary administration to potential students in the Army Heavy Antiarmor Weapons school (11H). Its cost/benefits for wider operational testing should be evaluated under different concepts of operations.
5. A variety of alternative tracking tests should be investigated, to determine if a mouse, trackball, or other off-the-shelf equipment could serve as well as slide potentiometers and joysticks. Human factors work on alternative tracking item types and screen displays should be supported.
6. Development of alternate forms and/or adaptive item pools should be started for the most promising ECAT tests.
7. The most promising ECAT tests should be normed.
8. Research on optimal non-negative weighting of ASVAB tests for maximal cross-validated classification efficiency should be given high priority. Operational selector composites eventually should be replaced by these optimal weighting methods.
9. Military training schools should be encouraged to incorporate continuously-scored practical performance measures in their intermediate and final grades. The statistical properties of Final School Grades, including reliability and validity, should be continuously monitored and updated, particularly following any shift in curricula.

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Introduction

Purpose

This report describes the Enhanced Computer Administered Test (ECAT) battery and the results from the Joint-Service validity study that evaluated the battery, which was the largest validation of a single computerized test battery ever undertaken.[1] ECAT has a significance beyond this simple fact; it may fundamentally alter the future of military aptitude testing. To better understand the importance of ECAT, including how it came about, the first section of this report places ECAT in the larger context of the last decade of military aptitude research. The second section describes subjects in the validity study, the content of the ECAT battery and its factor structure. ECAT is then contrasted with the Armed Services Vocational Aptitude Battery (ASVAB), which is the present military selection battery. The results of the ECAT validity study are then described in some detail, followed by conclusions.

Historical Background

We are nearing the culmination of a 10-year wave of research on military manpower testing, the largest since World War II. The impetus for this research began in 1973, following the end of the Vietnam War when the draft was terminated and the Services reverted to an All-Volunteer Force. Over the next decade the quality of service applicants declined severely (Eitelberg, Laurence, Waters, & Perelman, 1984), as did the quantity (Ramsberger & Means, 1987; Laurence & Ramsberger, 1991). Further complicating the grim manpower outlook was the military's tremendous technological modernization, a development placing even greater intellectual demands on the average enlistee. Yet even as the military's need for talented people grew more acute, our tools for identifying talent (i.e., aptitude tests) came under growing attack from critics. In 1978, the *Uniform Guidelines on Employee Selection Procedures* (EEOC, 1978) were adopted by the Federal Government — an action that, in part, led to the 1981 Congressional directive requiring that the Services better document the relationship between education, test scores, and actual job performance.

Collectively, these forces fostered a modern, resurgent interest in military manpower testing beginning in 1981. The focus of these efforts was to improve the ASVAB since it was the sole military selection battery. There were two main *ASVAB improvement* themes. One was an effort to *reformat* the ASVAB and improve the measurement properties of the battery. The other theme was to add new aptitude constructs and thus *broaden* the ASVAB. The underlying logic was straightforward. If we had more accurate and greater information about an applicant's intellectual

[1] While this was a Joint-Service study that received technical guidance from several Joint-Service committees, as the lead Service laboratory the work was conducted by the Navy Personnel Research and Development Center. In particular, Kathleen E. Moreno was solely responsible for the data collection effort; she let and monitored the data collection contract, obtained all the necessary military command approvals for testing, insured that equipment was manufactured and available, that test administrators were hired and trained, and throughout the conduct of the study she maintained an intimate relationship with the telephone, handling daily crises and logistics. Without her dedicated hard work, there would have been no ECAT study.

strengths and weaknesses, then the military would be better able to select and place applicants; psychometrically, this amounts to increasing validity. By increasing validity, it was expected that job performance would increase, job satisfaction would increase, attrition would be reduced, and collectively the military would be more capable.

Computerized Adaptive Testing Version of the Armed Services Vocational Aptitude Battery: CAT-ASVAB

The ASVAB reformatting project was CAT-ASVAB which formally began in 1979 when the Navy Personnel Research and Development Center was designated as Lead Laboratory for Computerized Testing. The program's approach was shaped by two technological advances: the availability of powerful microcomputers and developments in statistical theories of test scores. Blending these two advances produced the concept for CAT-ASVAB which was to develop a computer administered version of the ASVAB redesigned using modern psychometric theory, referred to as Item Response Theory. By combining Item Response Theory with computer administration, the ASVAB's power tests could be made adaptive by specifically selecting test items for an examinee based on his or her previous responses. Adaptive test administration could reduce test length by as much as one-half while improving reliability, particularly in the extremes of score distributions where applicant discrimination was poor. Administratively, computer-based testing could improve test security, reduce scoring errors, and provide immediate feedback to examinees and their recruiters.

Although adaptive tests had been a theoretical possibility for a number of years, no one had ever successfully produced an adaptive, multiple aptitude test battery intended for large-scale use. As such, hundreds of difficult, pragmatic, and unanticipated problems had to be solved in the development of a working CAT-ASVAB system. There were problems such as how the system should be organized, what fail-safe and failure-recovery procedures should be included, what hardware and networking system should be chosen, how items should be protected, and how the frequency of item use should be controlled. These and many more problems were solved to produce a functional delivery system.

More importantly though, there were several critical research questions that had to be answered as a prelude to operational use. One issue was a concern that the medium of administration alone (i.e., paper-and-pencil (P&P) versus computer), would produce important differences in test items and scores. A large scale 1987 study explicitly addressed this concern and found it to be generally unwarranted (Hetter, Segall, & Bloxom, 1992). A second concern was that test score intercorrelations, within and across mediums of administration, would differ markedly. This issue was addressed in an important 1988 study (Moreno & Segall, 1992) and the results clearly demonstrated that there were no substantial differences among the intercorrelation matrices of ASVAB tests, either within or across test mediums.

Having solved the practical testing issues and assuaged the concerns of many psychometricians and policy makers, a final step was required before CAT-ASVAB could actually be used. Specifically, conversion or equating tables were required that would allow CAT-ASVAB and P&P ASVAB scores to be used interchangeably. In 1988, an elaborately designed study was conducted, requiring data collection in several sites across the country. The data were used to develop preliminary tables equating CAT and ASVAB test scores. However, since the original equating tables were based on individuals who were required to take several nonoperational versions of the ASVAB, the validity of the equating tables had to be verified in one final study. This study was initiated, and as a result, in September 1990, CAT-ASVAB was operationally used for the first time. CAT-ASVAB has become the first operational, computer administered, adaptive selection and classification battery in use.

Enhanced Computer Administered Tests: ECAT

While efforts to reformat the ASVAB were focused and localized, attempts to *broaden* the abilities measured by the ASVAB were dispersed, with each of the services conducting research. In 1981 the Army's Project A was commissioned with a very broad charter and sweeping objectives. In the same time frame, the Air Force's Learning Abilities Measurement Project (LAMP) began with the goal of developing new predictors of learning. Smaller testing programs were also started in the Navy.

Several common contextual stimulants independently shaped the Services' attempts to broaden the ASVAB, producing similarities in their research programs. For example, the availability of inexpensive microcomputers and the momentum behind the computerization of the ASVAB, led the Services to develop new tests that were primarily computer-based. Moreover, the cognitive *zeitgeist* in American psychology during the mid-1970s and 1980s strongly influenced the programs. For example, all of the Services investigated the use of reaction time measures; the Air Forces' program was built around a cognitive model; and, the Navy's research was driven by cognitive theories of aptitude, working memory, and mental imagery.

Though there were commonalties across Services, there was little collaboration. However, as work on CAT-ASVAB progressed and a national renorming of ASVAB was anticipated, additional impetus was provided to the possibility of adding new aptitude dimensions to the ASVAB. In December of 1988, the Office of the Assistant Secretary of Defense (Force Management and Personnel) (OASD/FM&P) redirected the CAT-ASVAB program to "include a Joint-Service validation of the Services' new computerized cognitive and psychomotor tests" (Sellman, 1988). This directive was in recognition of two facts. First, an early cost-benefit study suggested that fielding a computer version of the ASVAB may not be cost effective relative to the P&P version. (This assessment has since been rendered obsolete by the plummeting prices of computer technology and by subsequent experience with an operational CAT system.). Second, other research indicated that broadening the ASVAB's ability measures could result in large improvements in productivity per accession (Schmidt, Hunter, & Dunn, 1987). Combining these findings, a new computer-based ASVAB augmented with new ability measures could produce a better and cost effective selection and classification system. Just as importantly though, the directive was a realization that if decisions were to be made about the usefulness of new ability measures, they needed to be evaluated in a single study using the most probable delivery system for a computerized ASVAB, the CAT-ASVAB system. This formally integrated the two research strains to improve the ASVAB.

In response to OASD's redirection, the Technical Advisory Selection Panel (TASP) was established in January of 1989 to evaluate and select tests for the Joint-Service validation battery. The panel's charter was to select the best tests in terms of their psychometric properties and theoretical justifications within the constraint that the battery could not exceed three hours. Across Services, hundreds of pages of documentation were submitted supporting the use of dozens of new aptitude measures[2]. Nine tests were chosen and combined into a battery named ECAT. A research design was approved, the necessary software and hardware were developed and/or acquired, and in February 1990 the study began. Twenty-one months later, testing ended. The sample included enlisted personnel in the Army, Navy, and Air Force representing 18 Military Occupational Specialties (MOS). (Additional details will be provided in later sections.)

Enhanced Computer Administered Test Validity Study

Enhanced Computer Administered Test Sample

Over 11,700 enlisted personnel were tested with the ECAT battery in the Navy, Army, and Air Force. Individuals were tested prior to entering training in one of 18 different MOSs (these will be described later). The sample was 95.5% male and 97.5% used English as their dominate language. Nearly 84% of the sample had obtained a high school diploma, an additional 6.7% had at least some college level schooling; only 9.5% failed to complete high school.

For descriptive purposes subjects were divided into six *ethnic* groups: Caucasian, Afro-American, Asian, Hispanic, North American Indian, and other. The categories are a combination of the population and ethnic group codes taken from enlistment records. *Caucasian* was defined by the population code Caucasian (C) and the ethnic code none (Y). *Afro-American* was defined by the population code Negroid/African/Black (N) unless a Hispanic ethnic code was also checked (then the person would be defined as Hispanic, see below). The *Asian* group was defined by the population code Asian/Mongoloid/Yellow (M) and/or ethnic codes for other Asian descent (3), Filipino (5), Chinese (G), Japanese (J), Korean (K), Vietnamese (V), Melanesian (E), Micronesian (W), Polynesian (L), and other Pacific Island descent (Q). Regardless of the population code, the *Hispanic* group was defined by ethnic codes for other Hispanic descent (1), Puerto Rican (4), Mexican (6), Cuban (9), and Latin American with Hispanic descent (S). The *North American Indian* group was defined by the population code for American Indian/Red (R) and by ethnic codes for U.S./Canadian Indian Tribes (2), Eskimo (7), and Aleut (8). A final group labeled *Other* was created from the population code Other (X) and the ethnic codes Other (X) (unless Caucasian), Indian (from India; D), and Unknown (Z). The distribution of subjects

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[2] The contributions of the TASP to the planning and design of this project are greatly appreciated. The panel was chaired by Dr. Bruce Bloxom, who provided the overall framework by which the proposed tests were to be evaluated, provided leadership, organization, and technical quidance, and documented the deliberations of the panel in the minutes of the meetings.. Clint Walker, of the Army Research Institute,. Lonnie Valentine, from the Air Force Human Resources Laboratory , and John Wolfe, from the Navy Personnel Research and Development Center, provided detailed proposals for tests to be considered by the panel. The panel also proposed and decided on the particular samples that were to be collected, and established contacts for arranging the testing of research subjects.

across the six ethnic groups was 71.1% Caucasian, 16.5% Afro-American, 5.9% Hispanic, 2.2% Asian, 0.8% North American Indian, and 3.4% Other/Unknown.

Enhanced Computer Administered Test Content

The goal of ECAT was to broaden the ASVAB. Table 1 shows the 10 tests that comprise the ASVAB. These tests represent Verbal Ability, Mathematical Ability, Technical Knowledge, and Perceptual Speed. Across Services, the ASVAB's four factor structure was the focal or starting point for new predictor research. Specifically, the assumption was made that the scope of human intellectual and nonintellectual skills was much greater than that represented by the ASVAB, and that capturing this breadth held the greatest promise for improving personnel selection and/or classification.

Table 1

Tests in the Armed Services Vocational Aptitude Battery (ASVAB)

Construct	Test	Description
Verbal	Paragraph Comprehension (PC)	A 15-item reading comprehension test
Ability	Word Knowledge (WK)	A 35-item vocabulary test using words embedded in sentences or synonyms
	General Science (GS)	A 25-item knowledge test of physical and biological sciences
Math Ability	Arithmetic Reasoning (AR)	A 30-item arithmetic word problem test
	Math Knowledge (MK)	A 25-item test of algebra, geometry, fractions, decimals, and exponents
Technical	Mechanical Comprehension (MC)	A 25-item test of mechanical and physical principles
Knowledge	Auto and Shop Information (AS)	A 25-item knowledge test of automobiles, shop practices, tools, and tool use
	Electronic Information (EI)	A 20-item test about electronics, radio, and electrical principles and information
Clerical Skills	Numerical Operations (NO)	A 50-item speeded addition, subtraction, multiplication, and division test using one and two digit numbers
	Coding Speed (CS)	An 84-item speeded test requiring the recognition of number strings arbitrarily associated with words in a table

Table 2 shows the 9 tests that comprise the ECAT battery including a brief description of each test. The battery requires a maximum of 3 hours with most individuals finishing in under

2 hours. The tests are grouped by the aptitude construct they were designed to measure: Nonverbal Reasoning, Spatial Ability, Psychomotor Skill, and Perceptual Speed. The tests were administered on Hewlett-Packard portable IPCs, which are the delivery systems for the Computerized Adaptive Testing version of the ASVAB (CAT-ASVAB). The keyboard was modified by using a plastic mask that revealed only the designated response keys along with a key labeled *HELP* that could be pressed during testing to suspend the program and request assistance. The *S*, *F*, *H*, *K*, and *;* keys were relabeled: *A*, *B*, *C*, *D*, and *E*. The space bar was relabeled *ENTER*. The numeric keypad keys retained their meanings. The last three ECAT tests used a custom-made input device referred to as a response pedestal. The response pedestal has color-coded buttons, two slide-potentiometers, and two joy-sticks which are used to respond to items (see Figure 1). In addition, the response pedestal contains a key labeled *HELP* that behaved like the corresponding key on the keyboard.

Table 2

Tests in the Joint-Service ECAT Battery

Construct	Test	Description
Nonverbal Reasoning	Mental Counters (CT)	A 40-item Working Memory test using figural content; a nonverbal reasoning test
	Sequential Memory (SM)	A 35-item Working Memory test using numerical content; a nonverbal reasoning test
	Figural Reasoning (FR)	A 35-item series extrapolation test using figural content; a nonverbal reasoning test
Spatial Ability	Integrating Details (ID)	A 40-item spatial problem solving test
	Assembling Objects (AO)	A 32-item spatial and semi-mechanical test
	Spatial Orientation (SO)	A 24-item spatial apperception/rotation test
Psychomotor Skill	One-Hand Tracking (T1)	An 18-item single limb psychomotor tracking test
	Two-Hand Tracking (T2)	An 18-item multi-limb psychomotor tracking test
Perceptual Speed	Target Identification (TI)	A 36-item reaction time-based figural perceptual speed test

Note. ECAT = Enhanced Computer Administered Testing.

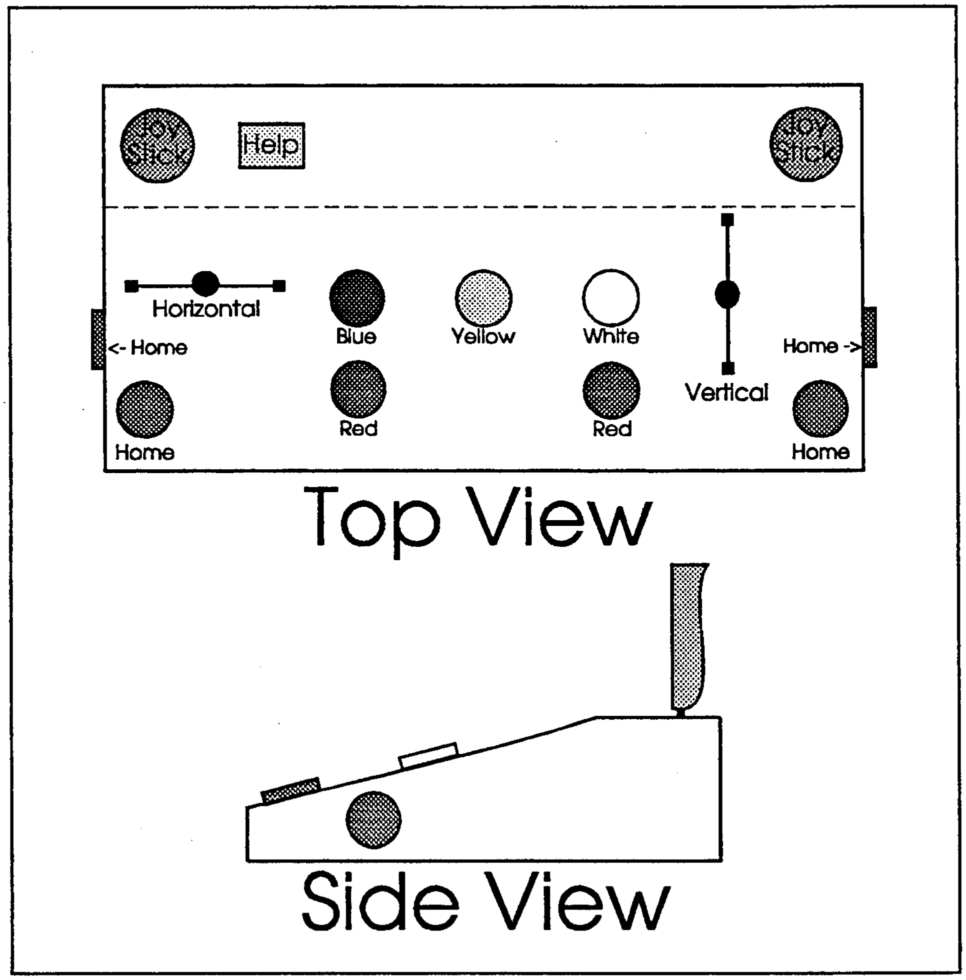
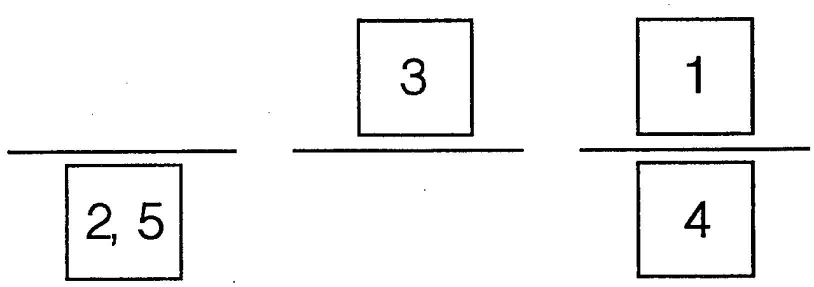


Figure 1. Response Pedestal (two views).

Since most of the ECAT tests are quite novel, a brief description of each test is warranted. Each test will be illustrated with a sample item accompanied by an abstract of the actual instructions, which often require five to ten screens, some with animation.

Nonverbal Reasoning Tests

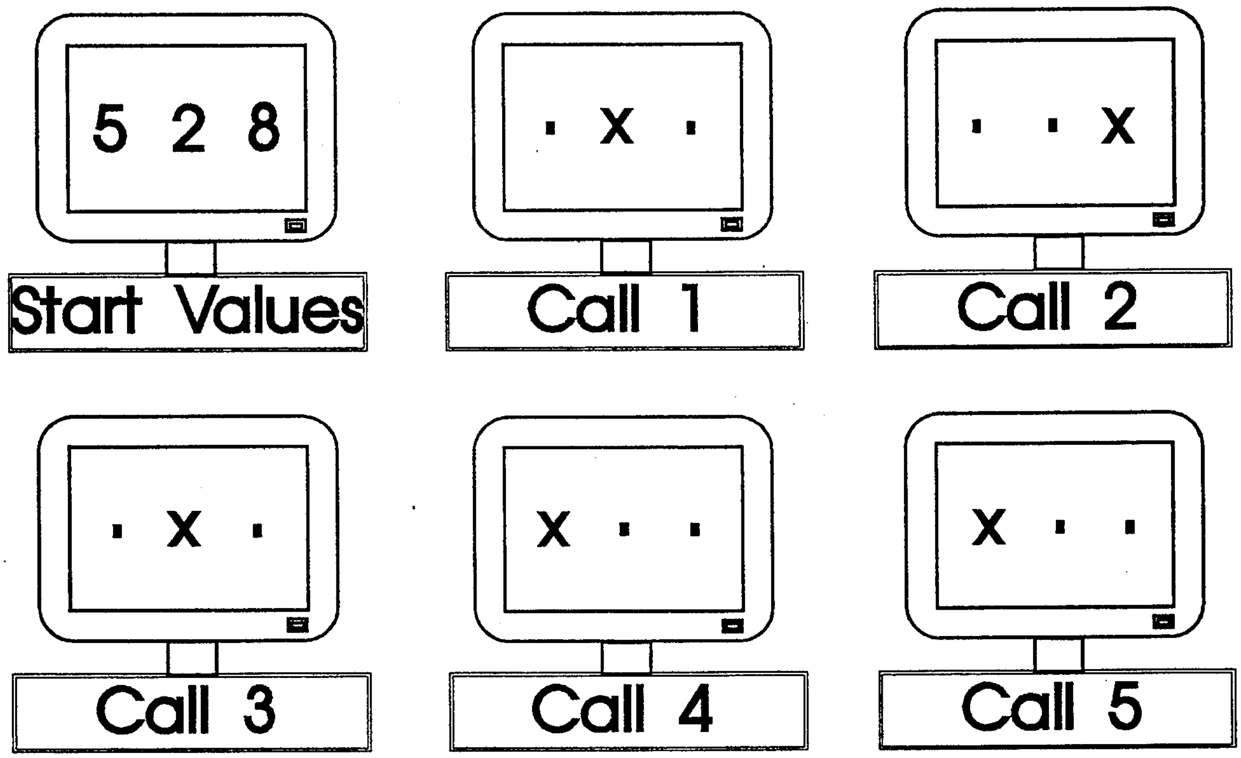
Mental Counters (CT)--is a complex 40 item working memory test. See Figure 2 for an example. Each screen contains three horizontal lines, arrayed left to right. Each line represents a counter with an initial value of zero. During an item, boxes appear sequentially, one at a time, either above or below one of the three lines. If a box appears above a line, the value for that counter is incremented by +1. If a box appears below a line, that counter is decremented by 1. On each trial either five or seven boxes appear. The boxes appear at one of two rates, either one every 1.33 seconds or one every .75 seconds. The task is to make a series of rapid calculations and to select, from a four-alternative multiple choice menu, the set of correct final counter values. Number of correct responses is the summary score.



Three independent counters (center horizontal lines) begin with starting values of 0. Boxes are sequentially displayed, then removed, in the order shown. If a box appears above a line the counter is incremented by 1, if below the line, it is decremented by 1. The final counter values for this item would be (in order) -2, +1, 0.

Figure 2. Mental Counters test.

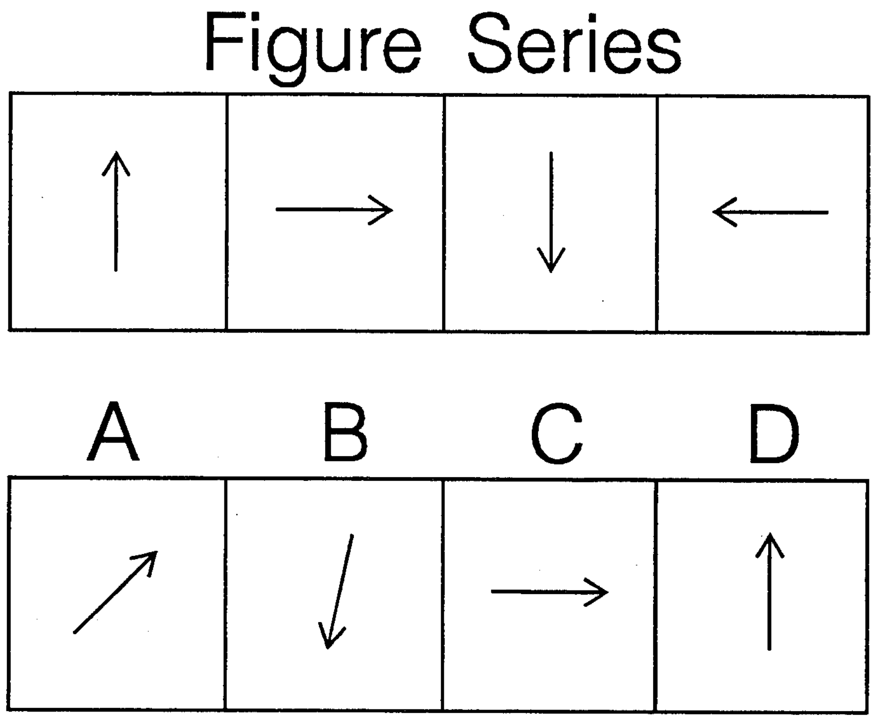
Sequential Memory (SM)--is another complex test of working memory. See Figure 3 for an example. Each item consists of three to five horizontally arrayed dots on the screen. Each dot is given a numerical value; these must be memorized. The item is then presented in a series of 5 to 7 "calls" to the dots; where each call is announced by briefly turning one of the dots into an "X." The person must report the digit string that corresponds to the order that the dots were "called." In the second half of the test, after all the calls for an item have been made, the examinee is told to translate each number in the ordered number list into a different number and then type in the new ordered list. There are 10 items in the first half of the test and 25 in the second half of the test. The dependent variable is the proportion of digits correct.



The start values indicate the numbers assigned to each position. Following this, each time an X appears, it "calls" the corresponding number. When the X appears in the center position, the 2 is called. When the X appears in the left position, the 5 is called. When the X appears in the right position, the 8 is called. Remember the sequence of calls. (Answer: 2, 8, 2, 5, 5)

Figure 3. Sequential Memory test.

Figural Reasoning (FR)--is a figural inductive reasoning (or series extrapolation) test. See Figure 4 for an example. Items use a combination of geometric forms and arbitrary figures presented in a series of four frames. The task is to induce the transformation rule controlling the series and then select one of five alternatives that correctly completes the series. The dependent variable is number correct of 30 items.

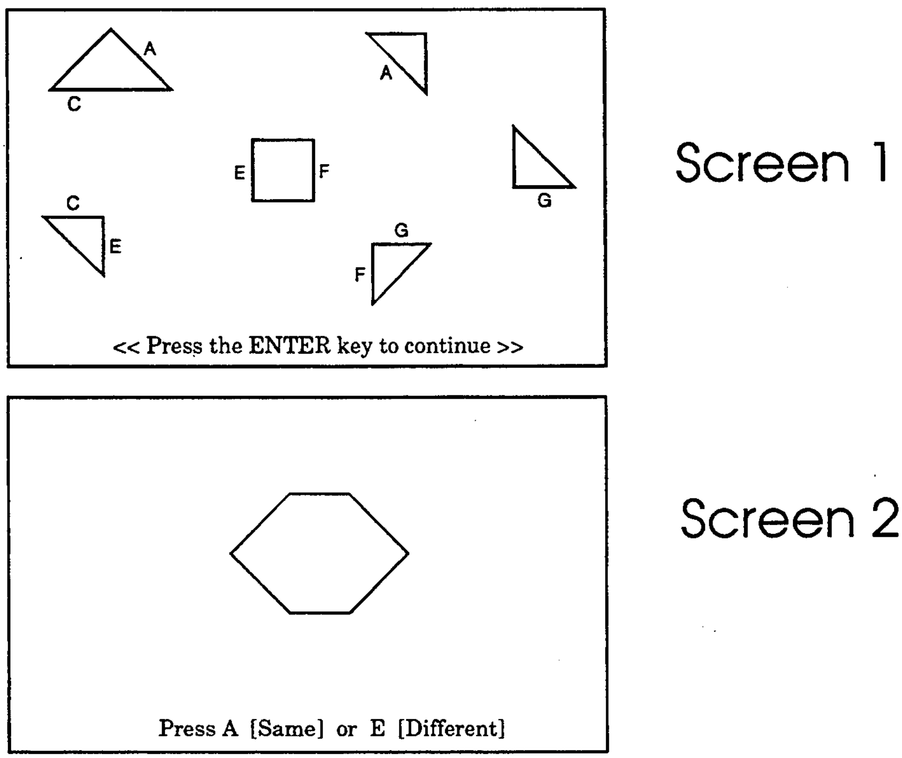


Which alternative shows the next frame in the figure series? (Answer: D)

Figure 4. Figural Reasoning test.

Spatial Ability Tests

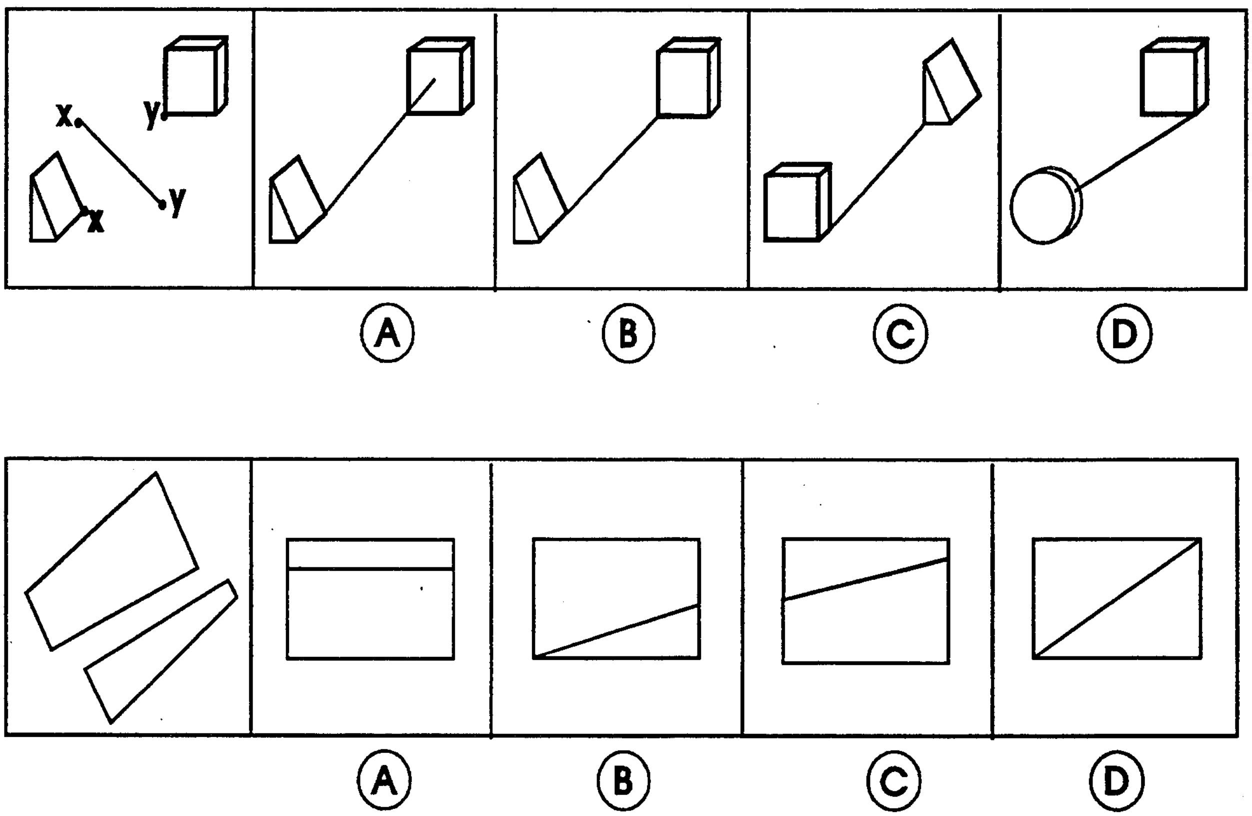
Integrating Details (ID)--is a complex 40 item spatial problem solving test. See Figure 5 for an example. Each item consists of two separate screens. The first screen contains from two to six regular geometric puzzle pieces that must be mentally fused to form a complete object. This is much like a jig-saw puzzle. Having connected all of the puzzle pieces, the individual must remember the final object, then press a response key. The puzzle pieces are replaced by a new screen with a single completed object. The task is to indicate if the displayed object is the product of the original puzzle pieces. Accuracy is the dependent measure.



The top frame is presented and the examinee has as long as necessary to mentally construct a complete object. Following a key press, the bottom frame is presented. The subject has as long as necessary to decide if the puzzle pieces would have constructed this object. Toggling between screens is not allowed. (Answer: Same.)

Figure 5. Integrating Details test.

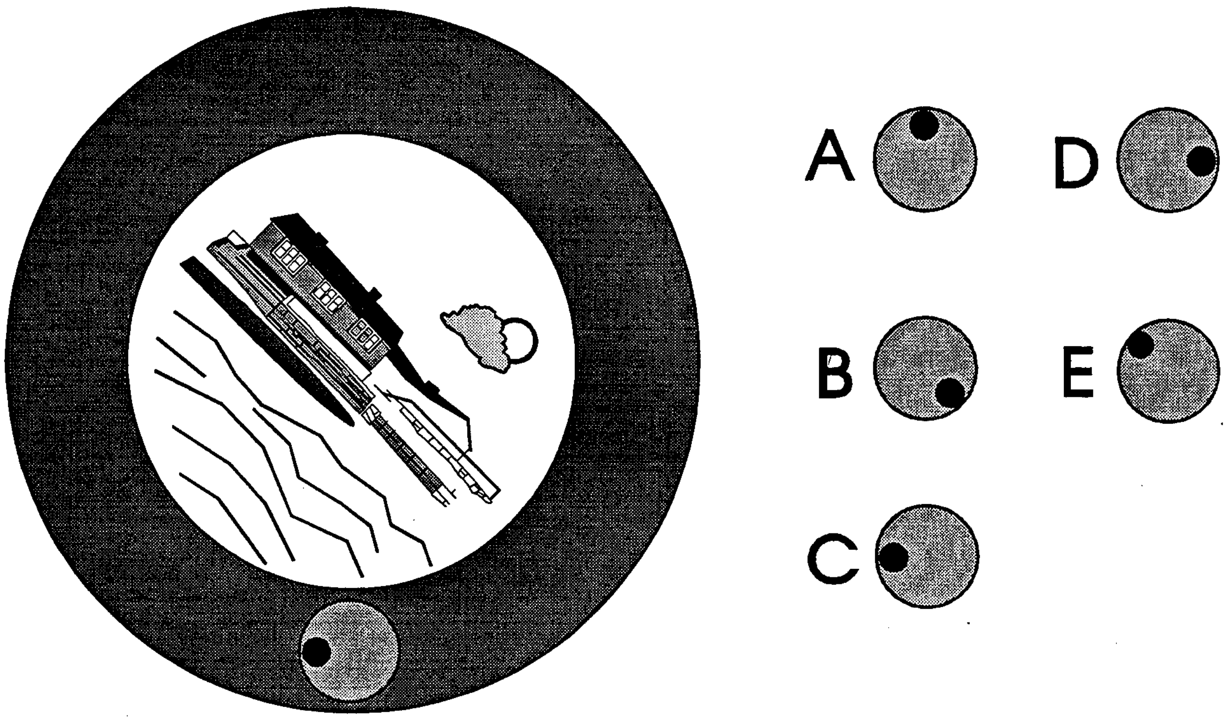
Assembling Objects (AO)--is a spatial construction test. See Figure 6 for an example. Each item consists of a frame with several (2-6) separate elements. The task is to choose from four alternatives the answer that correctly represents how the elements should be connected. There are 32 items in the test. The first 15 items are semi-mechanical items with labels indicating how the elements should be connected. The final 17 items consist of a disheveled jig-saw and four complete ones; the task is to chose the correct alternative. The dependent variable is number correct.



Which alternative shows the correctly constructed object?
(Answers: Top, B; Bottom, C)

Figure 6. Assembling Objects item types.

Spatial Orientation (SO)--is a spatial perspective test. See Figure 7 for an example. Each item consists of an environmental view, such as a bridge over a river or a house with an apparent horizon. These views are rotated away from the "natural" horizon. At the bottom of the frame is a circle with a dot on the perimeter. The task is to rotate the frame around the view until it corresponds with the natural horizon and determine where the dot on the circle would be located. This information is used to select which of five alternatives correctly shows the dot following rotation. The dependent variable is the number of items correct.

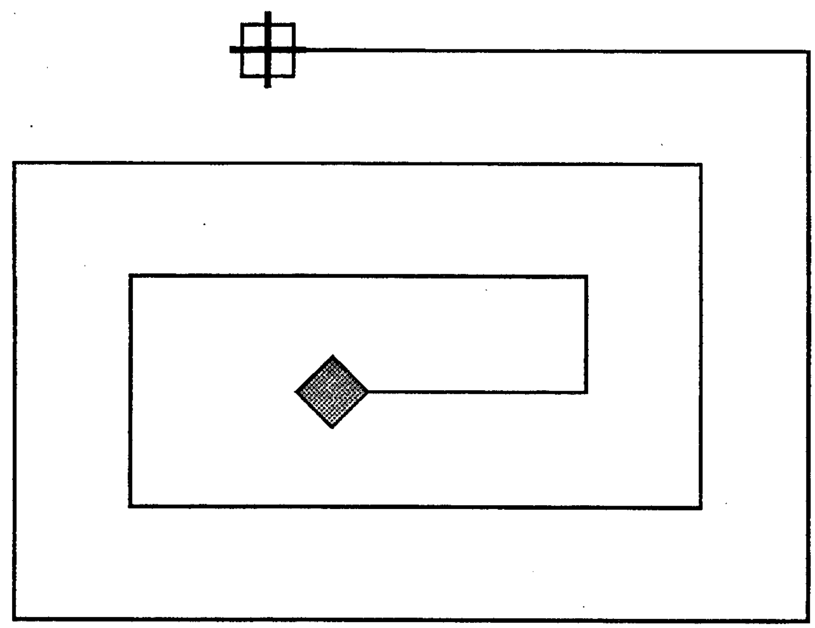


The sample problem contains a picture with a frame around it. The bottom of the frame has a circle with a dot inside, carved into the frame. Imagine that <u>only</u> the frame can be turned, and the picture inside can <u>not</u> be moved. Then, to match up the bottom of the frame with the bottom of the picture, you would turn the <u>frame</u> until the circle with a dot is located at the bottom of the picture. Your task is to figure out exactly what the circle with the dot inside will look like in its new position, after the frame has been turned. (Answer: E)

Figure 7. Spatial Orientation test.

Psychomotor Skill

One-Hand Tracking (T1)--is a psychomotor test that uses the response pedestal. See Figure 8 for an example. Each item begins with a "path" on the computer screen. The path is a contiguous string that goes up/down and/or right/left, parallel with the sides of the screen, making only 90 degree turns. At one end of the path is a diamond indicating the path's termination point. Starting at the other end is a box that travels forward along the path. The subject moves a joy-stick that controls the movement of a "cross-hair." The task is to keep the cross-hair on the moving box. Items vary in terms of the length of the path which is inversely related to the speed at which the box moves (total item duration is thus constant). For each item, the "score" is the average absolute Cartesian pixel distance between the cross-hair and the moving box (a distance reading is taken every 50 ms during the item). The dependent variable is the average distance-off-target across 18 items.



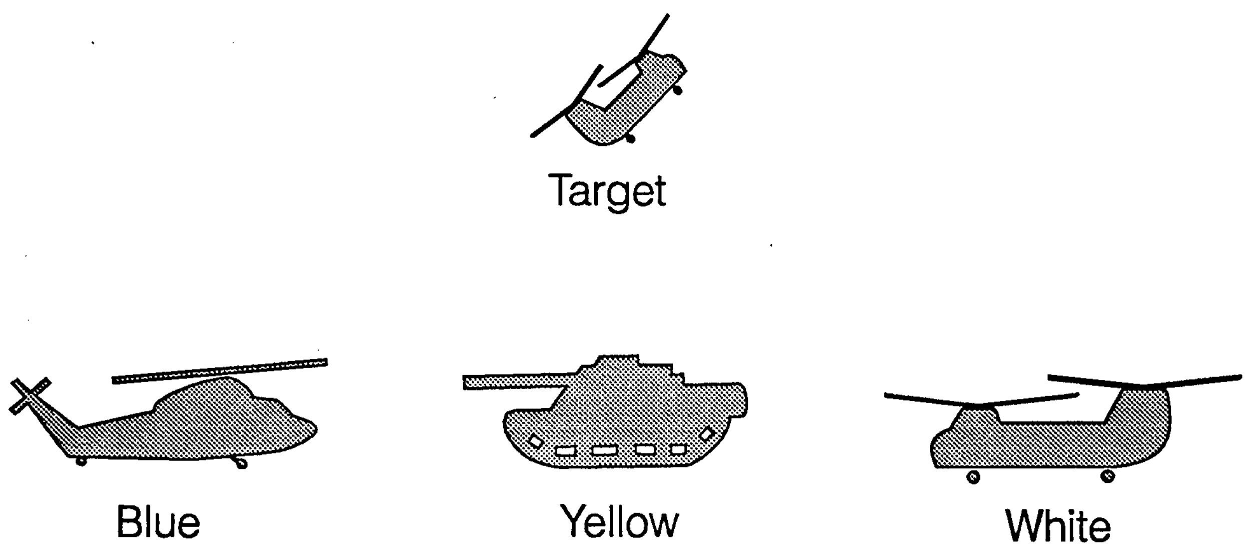
Keep the "cross hair" on the target (square) until the target movement stops (at the diamond).

Figure 8. One-Hand and Two-Hand Tracking items.

Two-Hand Tracking (T2)--is another psychomotor test that has exactly the same structure and task constraints as One-Hand Tracking (see Figure 8). The difference is that cross-hair movement is controlled by two slide potentiometers: one slide controls horizontal (left/right) movement while the other controls vertical (up/down) motion (see Figure 1). One hand must be used for each slide control. Number of items, scoring, and final score are the same as One-Hand Tracking.

Perceptual Speed

Target Identification (TI)--is a hybrid test combining aspects of choice reaction time and spatial mental rotation tests. See Figure 9 for an example. Each item consists of a target figure in the top half of the screen and three alternative figures in the bottom half. The figures are schematic line drawings of simple objects, such as trucks, helicopters, and tanks. The target may be rotated, distorted (e.g., shrunken), or both, but the correct alternative will be in a "natural" upright position. The task is to select the correct alternative as rapidly as possible. Before each item examinees must simultaneously press four "Home" buttons, two on the left and two on the right side of the response pedestal, essentially pinning their hands (see Figure 1). As soon as the examinee decides upon an answer, either hand may be used to press the button corresponding to the selected alternative. The dependent variable is the average correct decision time across the 36 items, where decision time is defined as the time between item presentation and button release.



While keeping fingers on Home keys, determine which object matches the Target, then press the correctly colored key. (Answer: White)

Figure 9. Target Identification test.

Six of the ECAT tests (i.e., FR, AO, SO, T1, T2, and TI) were developed by the Army Research Institute as part of Project A (Peterson, Hough, Dunnette, Rosse, Houston, & Toquam, 1990). The remaining three tests (CT, SM, and ID) were developed by the Navy Personnel Research and Development Center.

Descriptive Statistics

Table 3 contains simple descriptive statistics for the ASVAB and ECAT tests. The sample was lightly edited for unmotivated and extremely poor performing individuals before analyses were conducted. The first entry in Table 3, the Armed Services Qualification Test (AFQT), is, a composite of the mathematical (Arithmetic Reasoning and Mathematical Knowledge) and verbal (Word Knowledge and Paragraph Comprehension) tests and is used to determine eligibility for military service. The AFQT is also a good estimate of general intellectual performance. The AFQT composite is expressed as a cumulative percentile with a mean of 50 and a standard deviation of 28.7 in a nationally representative sample of service eligible individuals. The current sample had a mean AFQT of 60.3 and a standard deviation of 18.0. Thus, the sample was .36 standard deviation units above the mean resulting in a 37% reduction in the standard deviation due to explicit selection (truncating the lower tail of the distribution). The individual ASVAB tests are all scaled to a mean of 50 with a standard deviation of 10; they all show elevated means and truncated standard deviations due to selection effects. Little can be said about the ECAT tests except that they all have reasonable distributional properties and that the means and standard deviations reported here are similar to those found in other samples where the tests were used.

The last column of Table 3 contains uncorrected test reliability estimates. The ASVAB reliabilities are based on a 4 week retest period using alternate forms; the median reliability is .74 (Moreno & Segall, 1992). As described in Appendix E, the ECAT reliabilities were computed on a five week delayed readministration of the same forms; the median reliability is .80 (Larson & Alderton, 1992a, 1992b)

Table 4 shows the means, standard deviations, and correlations of the ASVAB and ECAT tests after correction for multivariate range restriction using the 10 ASVAB variables as explicitly selected variables with population covariances equal to those of the 1991 joint-services applicant population ($N = 650{,}278$).

Table 3

Descriptive Statistics for the ASVAB and ECAT Test Batteries

Test	Mean	Standard Deviation	Minimum	Maximum	Retest Reliability
Armed Forces Qualification Test (AFQT)	61.179	17.917	17.000	99.000	
General Science (GS)	53.255	7.419	23.000	69.000	.73
Arithmetic Reasoning (AR)	53.610	6.905	31.000	66.000	.77
Word Knowledge (WK)	53.044	5.354	20.000	61.000	.82
Paragraph Comprehension (PC)	53.229	5.740	20.000	62.000	.48
Numerical Operations (NO)	54.208	6.583	20.000	62.000	.71
Coding Speed (CS)	53.248	6.937	22.000	72.000	.75
Auto-Shop Information (AS)	53.614	8.051	28.000	69.000	.77
Math Knowledge (MK)	55.125	6.876	30.000	68.000	.82
Mechanical Comprehension (MC)	54.958	7.703	27.000	70.000	.70
Electronics Information (EI)	52.593	7.945	23.000	70.000	.65
Mental Counters (CT)	0.724	0.175	0.200	1.000	.79
Sequential Memory (SM)	0.688	0.134	0.160	1.000	.81
Figural Reasoning (FR)	0.669	0.188	0.100	1.000	.75
Integrating Details (ID)	0.760	0.127	0.375	1.000	.79
Assembling Objects (AO)	0.629	0.193	0.094	1.000	.83
Spatial Orientation (SO)	0.517	0.247	0.125	1.000	.75
One-Hand Tracking (T1)	2765.374	391.724	2003.611	4867.111	.84
Two-Hand Tracking (T2)	3639.163	471.978	2391.278	5460.722	.91
Target Identification (TI)	1.835	0.604	0.280	5.610	.80

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

Table 4

Range-Corrected Means, Standard Deviations, and Intercorrelations of ASVAB and ECAT Tests (N = 10,963)

Test	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
Mean	50.6150	50.6636	51.3114	51.1558	52.5122	52.2662	51.4087	51.2103	51.9408	50.3326
Std.Dev.	8.7726	8.6454	7.3541	7.9640	8.0131	7.8118	9.1677	8.6890	9.1272	8.8559
GS	1.0000	0.6111	0.7201	0.6079	0.2751	0.2487	0.5202	0.5542	0.6377	0.6245
AR	0.6111	1.0000	0.5963	0.5743	0.4703	0.3953	0.4004	0.7069	0.6134	0.4868
WK	0.7201	0.5963	1.0000	0.7316	0.3244	0.3278	0.4366	0.4968	0.5473	0.5344
PC	0.6079	0.5743	0.7316	1.0000	0.3959	0.3859	0.3391	0.4997	0.4852	0.4445
NO	0.2751	0.4703	0.3244	0.3959	1.0000	0.6401	0.0470	0.4961	0.2279	0.1452
CS	0.2487	0.3953	0.3278	0.3859	0.6401	1.0000	0.0583	0.4078	0.2212	0.1471
AS	0.5202	0.4004	0.4366	0.3391	0.0470	0.0583	1.0000	0.1966	0.6181	0.6692
MK	0.5542	0.7069	0.4968	0.4997	0.4961	0.4078	0.1966	1.0000	0.4939	0.3696
MC	0.6377	0.6134	0.5473	0.4852	0.2279	0.2212	0.6181	0.4939	1.0000	0.6304
EI	0.6245	0.4868	0.5344	0.4445	0.1452	0.1471	0.6692	0.3696	0.6304	1.0000
CT	0.3684	0.5582	0.3409	0.3529	0.3705	0.3490	0.2093	0.5163	0.4259	0.2685
SM	0.3606	0.5318	0.3682	0.3704	0.3412	0.3387	0.1703	0.4892	0.3854	0.2373
FR	0.5026	0.5945	0.4727	0.4425	0.3073	0.2872	0.3108	0.5457	0.5313	0.3914
ID	0.5024	0.5695	0.4310	0.3909	0.2601	0.2584	0.3787	0.5174	0.5743	0.4315
AO	0.4743	0.5142	0.3990	0.3611	0.2371	0.2669	0.3889	0.4675	0.5559	0.4254
SO	0.4888	0.5366	0.4392	0.3930	0.2250	0.2380	0.3955	0.4824	0.5622	0.4291
T1	-0.2882	-0.2956	-0.2440	-0.2272	-0.2008	-0.1967	-0.2589	-0.2608	-0.3677	-0.2659
T2	-0.3405	-0.3369	-0.2967	-0.2614	-0.1910	-0.2104	-0.3230	-0.2806	-0.4362	-0.3233
TI	-0.3151	-0.2651	-0.2537	-0.2224	-0.1781	-0.1917	-0.2274	-0.2300	-0.3216	-0.2349

Test	CT	SM	FR	ID	AO	SO	T1	T2	TI
Mean	0.6772	0.6554	0.6113	0.7209	0.5746	0.4447	2827.3	3722.98	1.9156
Std.Dev.	0.1920	0.1456	0.2106	0.1404	0.2112	0.2726	406.0732	494.5723	0.6219
GS	0.3684	0.3606	0.5026	0.5024	0.4743	0.4888	-0.2882	-0.3405	-0.3151
AR	0.5582	0.5318	0.5945	0.5695	0.5142	0.5366	-0.2956	-0.3369	-0.2651
WK	0.3409	0.3682	0.4727	0.4310	0.3990	0.4392	-0.2440	-0.2967	-0.2537
PC	0.3529	0.3704	0.4425	0.3909	0.3611	0.3930	-0.2272	-0.2614	-0.2224
NO	0.3705	0.3412	0.3073	0.2601	0.2371	0.2250	-0.2008	-0.1910	-0.1781
CS	0.3490	0.3387	0.2872	0.2584	0.2669	0.2380	-0.1967	-0.2104	-0.1917
AS	0.2093	0.1703	0.3108	0.3787	0.3889	0.3955	-0.2589	-0.3230	-0.2274
MK	0.5163	0.4892	0.5457	0.5174	0.4675	0.4824	-0.2608	-0.2806	-0.2300
MC	0.4259	0.3854	0.5313	0.5743	0.5559	0.5622	-0.3677	-0.4362	-0.3216
EI	0.2685	0.2373	0.3914	0.4315	0.4254	0.4291	-0.2659	-0.3233	-0.2349
CT	1.0000	0.6288	0.5586	0.5530	0.5700	0.5067	-0.3787	-0.3889	-0.2964
SM	0.6288	1.0000	0.5422	0.4939	0.4885	0.4583	-0.3162	-0.3343	-0.2807
FR	0.5586	0.5422	1.0000	0.5930	0.5768	0.5431	-0.3464	-0.3713	-0.2939
ID	0.5530	0.4939	0.5930	1.0000	0.6461	0.5736	-0.3808	-0.4061	-0.3287
AO	0.5700	0.4885	0.5768	0.6461	1.0000	0.5779	-0.3801	-0.4276	-0.3664
SO	0.5067	0.4584	0.5431	0.5736	0.5779	1.0000	-0.3668	-0.4084	-0.2815
T1	-0.3787	-0.3162	-0.3464	-0.3808	-0.3801	-0.3668	1.0000	0.7522	0.3631
T2	-0.3889	-0.3343	-0.3713	-0.4061	-0.4276	-0.4084	0.7522	1.0000	0.3844
TI	-0.2964	-0.2807	-0.2939	-0.3287	-0.3664	-0.2815	0.3631	0.3844	1.0000

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing. See Tables 1 & 2 for test names.

Adverse Impact

From inspection of the content of the sample items, one can conclude that the ECAT tests are relatively knowledge-free as compared with the ASVAB (i.e., they do not require knowledge acquired through formal education). They may be described as tests of fluid intelligence, rather than the crystallized intelligence measured by the ASVAB. Table 5 demonstrates this empirically by correlating the ASVAB and ECAT tests with Years of Education. With the exception of Auto-Shop Information, the ASVAB correlations with education are generally larger than the ECAT correlations. The correlations were not corrected for range-restriction, but such corrections should increase the correlation with education more for the ASVAB tests, which are explicitly used for selection, than for the ECAT tests. Lower correlations of the ECAT tests with education should cause the ECAT tests to have less adverse impact on educationally disadvantaged subgroups.

Table 5

Correlations of ASVAB and ECAT Tests With Years of Education (N = 10756)

Test	Correlation with Years of Education
Armed Forces Qualification Test (AFQT)	.166 *
General Science (GS)	.085 *
Arithmetic Reasoning (AR)	.107 *
Word Knowledge (WK)	.109 *
Paragraph Comprehension (PC)	.078 *
Numerical Operations (NO)	.111 *
Coding Speed (CS)	.116 *
Auto-Shop Information (AS)	.011 ns
Math Knowledge (MK)	.179 *
Mechanical Comprehension (MC)	.058 *
Electronics Information (EI)	.064 *
Mental Counters (CT)	.058 *
Sequential memory	.049 *
Integrating Details (ID)	.055 *
Assembling Objects (AO)	.039 *
Spatial Orientation (SO)	.061 *
Figural Reasoning (FR)	.065 *
One-hand Tracking	.036 *
Two-hand Tracking	.014 ns
Target Identification (TI)	.014 ns

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

* $p < .01$. ns = not significant.

Table 6 confirms this hypothesis. It shows the differences in mean test scores between Caucasians, and Afro-Americans, Asians, and Hispanics (See Appendix F for further details). The four tests with the largest adverse impact are all ASVAB tests - GS, WK, AS, and MC. The subgroups differ on which tests have the least adverse impact, but the ECAT tests compare favorably with the ASVAB tests. Since the sample was explicitly selected by ASVAB scores, correction for range restriction should increase the adverse impact of ASVAB tests more than of ECAT tests.

Table 6

Subgroup Differences in ASVAB and ECAT Test Means

Variable	Caucasian - Afro-American Z	Caucasian - Asian Z	Caucasian - Hispanic Z
Years of Education	-.058 *	-.288 **	.133 **
Educational Level	.030	.265 **	-.146 **
Language	.006	-1.988 **	-.234 **
AFQT	.736 **	.302 **	.370 **
General Science (GS)	.818 **	.609 **	.475 **
Arithmetic Reasoning (AR)	.753 **	.187 **	.293 **
Word Knowledge (WK)	.736 **	.755 **	.532 **
Paragraph Comprehension (PC)	.515 **	.375 **	.219 **
Numerical Operations (NO)	.023	-.189 **	.022
Coding Speed (CS)	.142 **	-.073	.051
Auto-Shop Information (AS)	1.106 **	.829 **	.638 **
Math Knowledge (MK)	.164 **	-.396 **	-.017
Mechanical Comprehension (MC)	.901 **	.430 **	.440 **
Electronics Information (EI)	.719 **	.358 **	.344 **
Mental Counters (CT)	.656 **	-.100	.089 *
Sequential Memory (SM)	.445 **	.139 *	.248 **
Integrating Details (ID)	.729 **	-.023	.116 **
Assembling Objects (AO)	.713 **	.010	.097 *
Spatial Orientation (SO)	.694 **	.165 *	.169 **
Figural Reasoning (FR)	.546 **	.103	.196 **
One-hand Tracking	-.565 **	-.292 **	-.026
Two-hand Tracking	-.701 **	-.314 **	-.113 **
Target Identification (TI)	-.485 **	-.400 **	-.179 **

Note. ASVAB = Armed Services Vocational Aptitude Battery. ECAT = Enhanced Computer Administered Testing. Z values are differences in ECAT sample means divided by the Caucasian group standard deviations.

* p . .05   ** $p < .01$.

Factor Analysis

One of the goals in selecting tests for inclusion in the ECAT battery was to expand upon the domain of abilities measured by the ASVAB. To determine how successful the efforts were, factor analyses were conducted to determine: (1) the underlying dimensions in each test battery, (2) the overlap in measuring general intelligence across the batteries, and (3) the factor structure when both batteries are combined. A number of factor analytic solutions were obtained by varying factor extraction methods, number of factors extracted, method of rotation, and initial communality estimates. Only the hierarchical solutions will be described. For hierarchical analyses, a Promax rotation was used at the primary level(s) with the entire hierarchical solution orthogonalized using the Schmid-Leiman technique (Schmid & Leiman, 1957). In the Schmid-Leiman orthogonalization, the effects of the second-order (*g*) loadings are removed from the first-order loadings. These residuals of the first-order loadings will be reported, rather than the original first-order loadings, which are much larger. Therefore, residual loadings as small as .20 can be reported as useful, in contrast to the .40 standard that is commonly used for interpreting primary rotated solutions.

All analyses are based on the corrected correlations reported in Table 4. Appendix B contains the uncorrected and corrected correlations with other measures, as well.. The primary factor loadings before orthogonalization are reported in Appendix C.

Armed Services Vocational Aptitude Battery Factor Structure

Table 7 reports the results of the hierarchical solution for the ASVAB. In this and the next two tables, where the tests had Promax loadings greater than .40, the hierarchical residual loadings appear in bold-face type. The four primary factors are: (1) Technical Knowledge defined by Auto-Shop Information, Mechanical Comprehension, and Electronics Information; (2) Verbal Ability defined by Word Knowledge and Paragraph Comprehension; (3) Clerical Speed defined by Numerical Operations and Coding Speed; and (4) Mathematical Ability defined by Arithmetic Reasoning and Math Knowledge. The only factorially complex test is General Science, which splits its specific variance across the Technical and Verbal factors. This factor structure is routinely found to describe the ASVAB's intercorrelations. All of the tests load on the hierarchical general ability measure (*g*) which accounted for 40% of the intercorrelational variance.

Table 7

Orthogonalized Hierarchical Factor Solution for the ASVAB

Test	g	Technical	Verbal	Clerical	Math
General Science (GS)	.738	.245	**.241**	-.073	.135
Arithmetic Reasoning (AR)	.753	.164	.054	.110	**.303**
Word Knowledge (WK)	.782	.024	**.504**	-.009	-.025
Paragraph Comprehension (PC)	.703	.019	**.360**	.124	.023
Numerical Operations (NO)	.461	-.012	-.014	**.683**	.058
Coding Speed (CS)	.412	. 011	.036	**.654**	-.024
Auto-Shop Information (AS)	.402	**.776**	-.023	.027	-.089
Math Knowledge (MK)	.741	-.069	.003	.037	**.480**
Mechanical Comprehension (MC)	.632	**.488**	.017	-.005	.158
Electronics Information (EI)	.547	**.569**	.061	-.015	.028

Notes:.
1. ASVAB = Armed Services Vocational Aptitude Battery, . *g* = General Intellectual Ability.
2. Entries in bold correspond to Promax loadings greater than .40

Enhanced Computer Administered Test Factor Structure

Table 8 reports the results of the hierarchical solution for the ECAT battery. Three primary factors were found: (1) Spatial Ability defined by Integrating Details, Assembling Objects, Figural Reasoning, and Spatial Orientation; (2) Psychomotor Skill defined by the One- and Two-Hand Tracking tests; and (3) Working Memory which was defined by Mental Counters and Sequential Memory. This factor pattern roughly matches the *a priori* categorization of the tests described earlier, except that the Figural Reasoning Test loaded higher on the Space factor than on the Memory (i.e. Nonverbal Reasoning) factor, and the fourth construct of Perceptual Speed could not be verified. The Target Identification test, however, did not load highly on any of the first three factors. If the ECAT battery had included additional tests of perceptual speed, it is likely that Target Identification would have loaded on a fourth Perceptual Speed factor. All of the tests loaded on the general factor which accounted for just over 40% of the correlational variance.

Table 8

Orthogonalized Hierarchical Solution for ECAT

Test	g	Spatial	Psychomotor	Working Memory
Mental Counters (CT)	.690	.130	-.046	**.313**
Sequential Memory (SM)	.643	.019	.000	**.583**
Figural Reasoning (FR)	.703	**.210**	-.002	.149
Integrating Details (ID)	.751	**.279**	-.018	.009
Assembling Objects (AO)	.757	**.281**	-.036	-.003
Spatial Orientation (SO)	.677	**.231**	-.057	.033
One-Hand Tracking (T1)	-.484	.004	**.696**	-.017
Two-Hand Tracking (T2)	-.524	-.017	**.716**	.009
Target Identification (TI)	-.402	-.082	.241	-.021

Notes.
1. ECAT = Enhanced Computer Administered Testing, *g* = General Intellectual Ability.
2. Entries in bold correspond to Promax loadings greater than .40

Enhanced Computer Administered Test and Armed Services Vocational Aptitude Battery Factor Structure

Although the factor patterns appear quite different across the batteries this does not directly address the question of the degree of overlap between the batteries. A partial answer to this question can be found by correlating the general ability scores across the batteries. The range corrected correlation of the ECAT-*g* and ASVAB-*g* scores was a moderate .71, implying that while there is some redundancy across the batteries there is substantial uniqueness as well. A final factor analysis was conducted across the combined test batteries (19 tests); the results are reported in Table 9. The ASVAB primary factors (Technical, Verbal, Clerical, and Math) were relatively unchanged in the combined analysis. The Psychomotor factor for ECAT also reemerged intact in the combined analysis, The Space factor reemerged, although only Integrating Details and Assembling Objects have substantial loadings on Space, and both tests have higher loadings on another factor. The ECAT Working Memory factor appears to have captured the nonverbal reasoning variance in many of the ECAT tests and thus was recast as a nonverbal reasoning factor. This latter factor, begging the point that it is at the primary level, appears very much like a fluid intelligence factor. This result is not surprising. Alderton and Larson (1992a, 1992b) argue that the net effect of the efforts to expand the ability dimensions measured by the ASVAB was to augment the crystallized intelligence measures of the ASVAB with fluid intelligence measures, thus providing a more complete sampling of intellectual performance. Later in this report, however, we will present evidence showing that additional specific ability factors are also required to maximize incremental validity.

Table 9

Orthogonalized Hierarchical Solution of ASVAB With ECAT

Test	g	Reas	Tech	Verb	Motr	Cler	Math	Spat
General Science (GS)	.740	.012	.161	**.315**[c]	-.024	-.046	.119	.064
Arithmetic Reasoning (AR)	.762	.212	.152	.070	.038	.082	**.258**	-.126
Word Knowledge (WK)	.706	.016	.024	**.605**	-.004	-.015	-.049	-.014
Paragraph Comprehension (PC)	.637	.028	.025	**.449**	.006	.117	.004	-.042
Numerical Operations (NO)	.406	-.026	.010	-.019	-.013	**.725**	.101	-.018
Coding Speed (CS)	.371	.033	-.007	.048	-.008	**.690**	-.047	.077
Auto-Shop Information (AS)	.519	.003	**.727**	-.023	.011	.018	-.114	-.040
Math Knowledge (MK)	.699	.139	-.080	.029	.009	.096	**.425**	-.021
Mechanical Comprehension (MC)	.724	.125	**.353**	.038	-.058	-.015	.095	.074
Electronics Information (EI)	.616	-.024	**.477**	.091	-.001	-.003	.040	.025
Mental Counters (CT)	.571	**.537**	-.004	-.041	-.037	.051	-.002	-.036
Sequential Memory (SM)	.536	**.534**	-.035	.054	-.006	.000	-.028	-.119
Figural Reasoning (FR)	.656	**.384**	-.001	.076	-.012	-.045	.079	.083
Integrating Details (ID)	.661	**.371**	.049	-.010	-.024	-.016	.062	.245
Assembling Objects (AO)	.633	**.421**	.044	-.023	-.008	.049	-.056	**.388**
Spatial Orientation (SO)	.630	**.316**	.099	.023	-.053	-.050	.056	.134
One-Hand Tracking (T1)	-.441	-.013	.017	.014	**.736**	.003	-.012	.021
Two-Hand Tracking (T2)	-.492	-.014	-.030	-.004	**.725**	.007	.003	-.001
Target Identification (TI)	-.365	-.115	-.012	-.048	.232	-.078	.067	-.152

Notes.
1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, *g*:=General Intellectual Ability, Motr: =Psychomotor Skill, Reas:= Nonverbal Reasoning, Cler: =Clerical Speed, Tech: =Technical Knowledge, Math: =Mathematical Ability, Verb: =Verbal Ability, Spat: =Spatial Ability.
2. Entries in bold correspond to Promax loadings greater than .40

The fact that the factor analysis of the combined ASVAB and ECAT battery produced three more factors than ASVAB alone shows that the ECAT battery indeed does measure ability factors not adequately measured by the ASVAB. Nevertheless, the overlap between the batteries is substantial, as shown in Table 10, which displays the correlations between the ASVAB and ECAT factor scores. Even within the ASVAB, the factor scores are highly correlated, as illustrated by the .72 correlation between Math and Verbal, but the .71 correlation between Math and Space is nearly as large.

Table 10

Range-Corrected Correlations Among ASVAB and ECAT Factor Scores

Factor	Verbal	Math	Technical	Clerical	Working Memory	Space	Psychomotor
Verbal	1.000	.722	.672	.489	.491	.587	-.365
Math	.722	1.000	.558	.647	.641	.711	-.405
Technical	.672	.558	1.000	.166	.387	.603	-.430
Clerical	.489	.647	.166	1.000	.472	.420	-.271
Working Memory	.491	.641	.387	.472	1.000	.789	-.480
Space	.587	.711	.603	.420	.789	1.000	-.605
Psychomotor	-.365	-.405	-.430	-.271	-.480	-.605	1.000

Note. ASVAB = Armed Services Vocational Aptitude Battery. ECAT = Enhanced Computer Administered Testing.

The same problem is evident at the second-order level with the correlations among the *g* factors derived from the different batteries. Table 11 shows that the ECAT and ASVAB *g* factor scores correlate a moderately high .71, which suggests some redundancy across the batteries, but which implies some uniqueness as well.

Table 11

Range-Corrected Correlations Between *g* Factor Scores From Different Batteries (N = 10,963)

Battery	ASVAB	ECAT	ASVAB + ECAT
ASVAB	1.000	.707	.948
ECAT	.707	1.000	.865
ASVAB + ECAT	.948	.865	1.000

Note. *g* = General Intellectual Ability, ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

Conclusions

The goal in selecting tests for the ECAT battery was to broaden the range of abilities measured by the ASVAB, the rationale being that this would maximize the probability that ECAT would improve the ASVAB's validity. The results suggest that the effort was largely successful. While the two *g* measures are highly correlated, they are by no means redundant. Although the ECAT spatial and nonverbal reasoning factors are also highly correlated with several ASVAB factors, substantial amounts of unique variance remain which may improve upon the ASVAB's validity. Moreover, the ECAT psychomotor and perceptual speed tests are nearly independent of the ASVAB and thus may capture aspects of training and job performance untouched by the ASVAB. Finally, the ECAT tests have less adverse impact than ASVAB tests because they measure fluid intelligence, rather than crystallized knowledge acquired in school.

Criteria for Validation

Background

In 1980, the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) directed the Military Services to establish a research and development program to link enlistment standards to job performance. Some of these job performance measurement projects were still underway at the beginning of the ECAT project, and we were fortunate to be able to arrange a cooperative effort with the Marine Corps to administer ECAT tests to automotive and helicopter mechanics at the same time that job knowledge and hands-on job performance tests were administered. The results of that study were presented by Carey (1994).

The samples described in this report all came from students at military technical training schools. Instead of relying on Final School Grades, as has been traditional for most validation studies conducted in service schools, every effort was made to collect information on practical skills taught in shop, laboratory, simulator, or other exercises. In many cases, these were hands-on performance measures similar to the kinds of tests used in Job Performance measurement projects.

Kieckhaefer et al. (1992) describe their development of the ECAT criteria. They collected data on every quiz, homework assignment, and laboratory/shop exercise for samples of several hundred students at each school. Based on factor analysis, they constructed composites of scores designed to measure different dimensions of achievement in each school. These composites will be referred to as "internal school criteria," because they are seldom published outside of the school, as the Final School Grades are. They include all of the hands-on performance measures, as well as composites of written tests, and grades on each learning module. Table 12, Table 13, and Table 14 list the 77 criteria that were used.

Table 12

Criteria in Army Courses for ECAT Validation

Location	Code	Title/Description
Fort Benning	**11H**	**Heavy Antiarmor Weapons Crewman**
	11H(A)	**HMMWV Curriculum:**
	TOALL	Sum of scores on 8 Training Objectives
	EVT1TO	TOW Tracking Time on Target for 10 shots, Event 1
	EVT2TO	TOW Tracking Time on Target for 10 shots, Event 2
	EVT3TO	TOW Tracking Time on Target for 10 shots, Event 3
	EVTSUM	Sum of Events 1-3 Scores
	TO_1	M966 TOW Simulator Tracking Event 1 Total
	11H(B)	**ITV Curriculum:**
	TOALL	Sum of scores on 8 Training Objectives
	EVT1TO	TOW Tracking Time on Target for 10 shots, Event 1
	EVT2TO	TOW Tracking Time on Target for 10 shots, Event 2
	EVT3TO	TOW Tracking Time on Target for 10 shots, Event 3
	EVTSUM	Sum of Events 1-3 Scores
	TO_1	ITV TOW Simulator Tracking Event 1 Total
	TO_2	ITV TOW Simulator Tracking Event 2 Total
	TO_3	ITV TOW Simulator Tracking Event 3 Total
	ITVTOW	ITV TOW Simulator Tracking Total Events 1-3
Fort Sill	**13F**	**Field Artillery Fire Support Specialist**
	MPRAD	Map Reading and Radio composite
	FIRING	Firing composite
	FSG	Final School Grade
Fort Knox	**19K**	**Tank Crewman**
	COMM	Communications Performance
	WEAPON	Weapons Maintenance and Preparation
	LANDNAV	Land Navigation and Map Reading
	LOADER	Load/Unload main tank gun and machine gun
	MAINT	Preventive maintenance and trouble shooting/repair
	NBC	Nuclear/Biological/Chemical countermeasures
	AVERAGE	Mean of the 6 scores above

Note. ECAT = Enhanced Computer Administered Testing, HMMWV = High Mobility Multipurpose Wheeled Vehicle, TOW = Tube-launched Optically-tracked Wire-guided missile, ITV = Improved Tow Vehicle, TO = Training Objective.

Table 13

Criteria in Navy Schools for ECAT Validation

CDP	School/Criteria	Title/Description
6278	**AC**	**Air Traffic Controller**
	PERF	Mean of 4 Performance Tests
6515	**AE**	**Aviation Electrician's Mate**
	SUM2	Average of Performance Tests loading on Factor 2
6518	**AMS**	**Aviation Structural Mechanic - Structures**
	PERF	Average of performance tests and practical work
6506	**AO**	**Aviation Ordnanceman**
	PRACTL	Average of all practical work
6239-41	**AV**	**Avionics Technician**
	BSCAV	Average of all Basic Avionics Tests
	ADVAV	Average of all Advanced Avionics Tests
	PERFORM	Average of all Performance Tests
6070	**EM**	**Electrician's Mate**
	PHASE 1	Average of all Phase I tests
6487	**EN**	**Engineman**
603V	**ET(AEF)**	**Electronics Technician - Advanced Electronics Field**
	FSG	Final School Grade for Phase I
	FSG2	Final School Grade for Phase II
	PERF	Average of Phase II Performance Tests
609W	**FC**	**Fire Controlman**
	RADAR	Average of all Radar Tests
6400	**GMG**	**Gunner's Mate - Gun**
	HALF1	Average of Tests 1-14
	HALF2	Average of Tests 14-27/30
6492	**MM**	**Machinist's Mate**
6540	**OS**	**Operations Specialist**
	WRIT	Average of all Written Tests
	PERF	Average of all Performance Tests
611E	**RM**	**Radioman**
	PHASE3	Average of All Knowledge and Performance Tests in Last Phase

Notes. 1. ECAT = Enhanced Computer Administered Testing, CDP = Course Data Processing code.

2. FSG (Final School Grade) was also used as a criterion in each school.

Table 14

Criteria in Air Force Schools for ECAT Validation

Location	AFSC/Criterion	Title
Keesler AFB	**73230**	**Apprentice Personnel Specialist (APS)**
	ZHRS	Standardized training hours on Blocks II-VII
	AFPT70	Air Force Performance Test Words per Minute Typing
	FSG	Final School Grade
Keesler AFB	**27230**	**Apprentice Air Traffic Control Operator (ATC)**
	BLK2	Control Tower Procedures (Written test – standardized hours)
	BLK3A	Basic Control Tower Operation (Perf test – standardized hours)
	BLK3B	Advanced Control Tower Operation (Perf test – standardized hours)
	BLK5A	Basic Approach Control Operation (Perf test – standardized hours)
	BLK5B	Advanced Approach Control Operation (Perf test – standardized hours)
	FAA	Federal Aviation Administration Examination
	FSG	Final School Grade

Note. ECAT = Enhanced Computer Administered Testing, AFSC = Air Force Specialty Code.

Several difficulties were encountered in the criterion development.

1. Many of the laboratory exercises were scored as Pass/Fail, with almost all of the students passing. Composites derived from these exercises were highly skewed with small variances.

2. Some schools had alternative tracks or major curriculum changes during the course of the ECAT study. Criteria that were available for one curriculum were absent in the next. In these cases, the sample from a given school had to be split into smaller subsamples, thus reducing statistical power.

3. The Trank Crewman (19K) school was selected for study because Smith and Graham (1987) had found excellent incremental validities with a combination of psychomotor and perceptual tests for predicting performance on the Unit Conduct of Fire Trainer (UCOFT), a high-fidelity tank gunnery simulator. Unfortunately, budget cuts at the school forced this simulator to be shut down. Other available criteria turned out to have low reliability.

Because of minor curriculum changes and other factors, most students missed one or more of the examinations or exercises that comprised the composite criteria. Therefore, the criteria were defined to be the means of the tests or exercises actually taken. However, these means were sometimes bizarre for students that dropped out from school early in the curriculum. In the course of the data analysis, rules were formulated to reduce the number of outliers due to missing data. These are described in Appendix E.

Criterion Statistics

Tables G-1, G-2, and G-3 show the basic statistics for some 77 criteria collected at three Army schools, two Air Force Schools, and 13 Navy schools. The Army's 11H school was divided into two curricula, labeled 11H(A) and 11H(B). The Air Force Air Traffic Control school (ATC) had two curricula, labeled ATC(A) and ATC(B). For some purposes, these were combined into a single group, ATC. In the tables, the digit at the end of the school abbreviation refers to the number of the criterion. Thus, 11H(A) had 6 criteria, while 11H(B) had 9 criteria.

Reliabilities were derived from those computed by Kieckhaefer et al. (1992) In several schools (19K, AV, ET, EN, MM, OS) different curricula were combined into one group, and the weighted average of the reliabilities of corresponding criteria was used.

To correct the criterion means and standard deviations for range-restriction, Lawley's (1943) multivariate range correction procedure was used, with all 10 ASVAB tests used as explicitly selected variables. The corrected reliability was computed from the formula

$$R_{XX} = (1 - \frac{s_x^2}{S_X^2})(1 - r_{xx}),$$

where r_{xx} is the uncorrected reliability, s_x is the uncorrected standard deviation, and the corresponding corrected values are in upper case (Gulliksen, 1950/1987, Chapter 10, Eq. 5).

Corrected reliabilities will be used in the last stage of correcting validities. Multiple correlations are first tested for significance, then corrected for range restriction, then corrected for bias using the Wherry formula, and finally divided by the square root of the corrected reliability. In cases where the uncorrected reliability was unknown or smaller than 0.35, no correlation for criterion reliability was used. Such cases are designated by a period in the reliability column of the tables.

Selecting Criteria for Meta-analysis

For some purposes, it will be necessary to compute mean validities or combine probabilities across schools. If all criteria were combined, schools with the most criteria would receive larger weights in the averages. Moreover, the criteria within a school are not independent, thus complicating the analysis. The best approach seems to be to select one criterion per school when combining results across schools.

Criterion reliabilities in the Army's 19K school were so low that all results from this school were reluctantly dropped from the meta-analysis.

Four sets of criteria were selected for averaging:

1. School Grades Because school grades have been the traditional measures of training success used in validation studies, we felt obligated to include an analysis in terms of school grades, even though we expected some of the ECAT tests, such as psychomotor tracking, to have no relation to the kinds of written tests that usually form the basis for final school grades. In the 11H Army school where FSG was unavailable, a summary average score, EVTSUM, was used. This was actually a hands-on performance measure.

2. Internal School Criteria Among the measures collected for each school, criteria were selected according to the following *a priori* rules, which were applied in order:

a.. If possible, the criterion is not the same as the School Grade. If there is no other criterion, then School Grade is chosen. This rule tries to minimize overlap between the Internal Criteria and School Grades.

b.. If possible, the criterion should be a practical performance score, rather than a knowledge score.

c.. If the reliabilities of two measures are substantially different (i.e. by 0.10 or more) then the more reliable one is used.

d.. A measure with greatest face or construct validity is to be preferred over others.

e.. A score collected late in training should be preferred to one taken earlier.

In the Army 11H school, after Rule (a) was applied, rules (d) and (e) resulted in selecting the TOW simulator tracking performance scores taken toward the end of training: TO_1 and ITVTOW. In the 13F school, face validity favored Firing as a criterion. In the Navy, there was never more than one performance criterion to choose from. The only remaining choice occurred in the GM school, where Rule (e) selected a measure taken in the last half of the course in preference to the earlier measure. In the Air Force APS school, the only practical performance criterion consisted of words per minute on the AFPT70 typing test.

One exception to the *a priori* selection was made in the Air Force Air Traffic Controllers, where Rule (c) suggested the BLK3B criterion for ATC(A) and the BLK5A criterion for ATC(B). However in order to maintain consistency with ATC(B), the preferred ATC(A) criterion was changed to BLK5A.

3. Final School Grades for 10 Schools with Performance Criteria Ten schools had both FSG and practical performance criteria available. For those samples, the corresponding two sets of criteria were used for some analyses. The 10 schools were 13F, APS, ATC, AC, AE, AMS, AO, AV, ET, and OS.

4. Performance Criteria for 10 Schools with Final School Grades These are practical performance measures on the same 10 schools for which FSGs were available. Because the Air Force ATC school was split into two different curricula, the number of samples was 11.

The last two sets of criteria are subsets of the first two, with sample sizes only a third of the total. However, they permit a strict comparison between FSG and performance criteria for the average magnitude of incremental validity[3].

[3]This analysis was suggested by Dr. Norm Abrahams, of RGI, Inc.

Validity of General Ability Factors

Theoretical Background

It has been argued that the search for additional tests to enhance the validity of ASVAB is futile. Many previous studies have shown that the general ability factor, or "*g*", is the major predictor of school and job performance, and the ASVAB is an excellent measure of *g* (Ree & Earles, 1991; Hunter, 1986).

Others have argued that *g* is imperfectly measured by the ASVAB, which seems to concentrate on verbal and numerical crystallized intelligence. Enhancing the ASVAB with spatial and reasoning tests, and tests which require fluid intelligence, should produce a better measure of *g* with greater predictive validity.

A third position is that *g*, although important, may be over-rated for predicting certain kinds of jobs requiring special abilities. Hence, additional tests of spatial and psychomotor ability, for example, should have incremental validity over ASVAB for predicting mechanical repair, targeting, vehicle operations, etc.

Method

Three different measures of *g* were developed, using the matrix of range-corrected correlations.

1. *Hierarchical* **g** scores were computed using weights derived from a second-order factor analysis of the variables.

2. *Principal Component g* was computed using the factor score weights from the first principal component. This method should maximize the variance accounted for by a single factor.

3. *Psychological* **g** scores were computed by weighting each test's z-score by its correlation with the Figural Reasoning test. The rationale was that the Figural Reasoning test measures the same fluid reasoning ability as the Raven Progressive Matrices test, which often has been used as a marker for *g*.

Each of these three methods were applied to three different sets of variables: ASVAB only, ECAT only, and ASVAB + ECAT combined.

The validity of each **g** score was computed for each criterion and corrected for multivariate range-restriction and criterion unreliability. The validity of the ASVAB + ECAT **g** was compared with the validity of the **g** derived from ASVAB alone. The significance of the difference was tested with an asymptotic test for range-corrected dependent multiple correlations (Hedges, Becker, & Wolfe, 1992, Eq. 12). When applied to zero-order correlations, this formula is equivalent to comparing the value of

$$z = \frac{(c_2 r_2 - c_1 r_1)\sqrt{n}}{\sqrt{c_1^2(1-r_1^2)^2 + c_2^2(1-r_2^2)^2 - c_1 c_2[2r_{12}(1-r_1^2-r_2^2) - r_1 r_2(1-r_1^2-r_2^2-r_{12}^2)]}}$$

with the (0,1) normal distribution, where

r_1 is the uncorrected validity of ASVAB **g**,

r_2 is the uncorrected validity of ASVAB + ECAT **g**,

r_{12} is the uncorrected correlation between ASVAB **g** and ASVAB + ECAT **g**,

c_1 is the ratio of range-corrected to uncorrected validity for ASVAB **g**,

c_2 is the ratio of range-corrected to uncorrected validity for ASVAB + ECAT **g**,

and n is the sample size.

For each school, a probability is determined by comparing the value of z with the upper tail of the normal distribution. The combined probability for the entire sample across schools is given by the chi-square distribution of $\sum_{i=1}^{Schools}(-2\log P_i)$ with $2 \times Schools$ degrees of freedom (Fisher, 1932). The degrees of freedom are 36 for the School Grade set and 38 for the Internal School Criteria Validities, where the Air Traffic Control school was split into two groups.

Mean validities were weighted averages of the multiple correlations for each school, weighted by their sample sizes.

Results

Table 15 shows the range-corrected correlations of the First Principal Component scores with Psychological and Hierarchical ***g*** factor scores for the three data sets. It is apparent the Psychological ***g*** is virtually identical to the First Principal Component. Hence Psychological ***g*** was eliminated from the subsequent validity analyses.

Table 15

Range-corrected Correlations of *g* With First Principal Components
(*N* = 10,963)

Battery	Psychological *g*	Hierarchical *g*
ASVAB	.999	.966
ECAT	.994	.985
ASVAB + ECAT	.998	.987

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

While the correlations between different measures of ***g*** within the same battery of tests are large, the correlations between batteries are considerably lower, as was shown by Table 11.

Table 16 and Table 17 present the validities of six different measures of ***g*** for School Grades and for Internal School Criteria, respectively. All validities were corrected both for range-restriction and for criterion unreliability. The mean validities were obtained by weighting these values by the sample sizes.

The mean validities for the Hierarchical ***g*** were smaller than the First Principal Component validities for the ASVAB battery only, but not for the ECAT only or ASVAB + ECAT batteries. This reversal makes interpretation difficult for subsequent comparisons. For the First Principal Component, the inclusion of ECAT tests does not significantly improve validity for predicting School Grades, while for the Hierarchical ***g***, ECAT significantly increases validity for five of the school samples as well as for the mean across schools A similar result was obtained for the Internal Criteria, with only the Hierarchical ***g*** showing a significant increase in mean validity.

Discussion

The hypothesis that the ***g*** derived from a broader sampling of tests contained in the ASVAB + ECAT battery will have greater validity seems to be confirmed by these data for Hierarchical ***g***.

As we shall see, full least squares multiple regression produces validities that average .02 to .06 larger than those for ***g*** for all batteries. This means that the validity partly comes from specific ability factors relevant to specific criterion measures, rather than from the general ability factor alone.

Table 16

Corrected Validities of Hierarchical and First Principal Component Measures of "G" From ASVAB, ECAT, and ASVAB + ECAT Sets of Variables for School Grade Criteria

			Index of	ASVAB		ECAT		ASVAB + ECAT	
School	Criterion	*N*	Reliability	Hier. G	P.C.	Hier. G	P.C.	Hier. G	P.C.
11H(A)5	EVTSUM	546	.981	.330	.354	.368	.376	.387*	.392
11H(B)5	EVTSUM	316	.981	.358	.388	.394	.425	.416*	.435
13F1	FSG	821	.894	.744	.774	.719	.709	.791*	.804
APS1	FSG	446	.933	.817	.812	.674	.649	.812	.797
ATC1	FSG	484	.914	.713	.722	.621	.624	.733	.729
AC1	FSG	72	.977	.782	.774	.636	.612	.769	.757
AE1	FSG	278	.961	.639	.669	.616	.607	.687	.691
AMS1	FSG	244	.965	.799	.843	.641	.631	.820	.803
AO1	FSG	234	.946	.694	.701	.582	.584	.706	.698
AV1	FSG	544	.983	.762	.772	.668	.654	.789	.776
EM1	FSG	797	.972	.654	.664	.539	.525	.665	.649
EN1	FSG	750	.956	.707	.751	.590	.582	.743*	.726
ET2	FSG2	86	.987	.779	.799	.761	.755	.828	.842
FC1	FSG	778	.983	.793	.817	.655	.632	.813	.791
GM1	FSG	420	.976	.709	.722	.588	.579	.727	.708
MM1	FSG	801	.948	.505	.546	.464	.452	.546*	.542
OS1	FSG	713	.955	.768	.768	.665	.649	.772	.771
RM1	FSG	277	.934	.761	.763	.606	.572	.743	.730
Mean	Grades	8607		.676	.696	.592	.582	.702**	.695

Notes. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, Hier. G = Hierarchical *g*, P.C. = first principal component.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for the null hypothesis of no difference from the corresponding ASVAB *g*. ** $p < .01$.

Table 17

Corrected Validities of Hierarchical and First Principal Component Measures of "G" From ASVAB, ECAT, and ASVAB + ECAT Sets of Variables for Internal School Criteria

			Index of	ASVAB		ECAT		ASVAB + ECAT	
School	Criterion	*N*	Reliability	Hier. G	P.C.	Hier. G	P.C.	Hier. G	P.C.
11H(A)6	TO_1	542	.945	.216	.221	.212	.234	.239	.244
11H(B)9	ITVTOW	318	.960	-.018	-.008	.078	.095	.046	.041
13F3	FIRING	821	.814	.690	.711	.612	.611	.713	.718
APS3	AFPT70	432	.965	.318	.286	.315	.278	.291	.308
ATC(A)4	BLK5A	205	.711	.432	.482	.624	.633	.549	.598
ATC(B)4	BLK5A	295	.911	.390	.375	.518	.532	.455	.485
AC2	PERF	76	.825	.287	.269	.497	.476	.345	.398
AE2	SUM2	273	.916	.548	.587	.545	.532	.601	.607
AMS2	PERF	244	.880	.532	.598	.553	.546	.602	.620
AO2	PRACTL	229	.871	.453	.448	.435	.437	.458	.478
AV4	PERFORM	352	.820	.507	.561	.561	.558	.608	.605
EM2	PHASE1	797	.943	.687	.687	.570	.552	.697	.676
EN1	FSG	750	.956	.707	.751	.590	.582	.743*	.726
ET3	PERF	86	.941	.643	.635	.632	.665	.684	.700
FC2	RADAR	780	.891	.682	.731	.543	.540	.712	.692
GM3	HALF2	397	.959	.687	.721	.561	.551	.709	.693
MM1	FSG	801	.948	.505	.546	.464	.452	.546*	.542
OS3	PERF	815	.896	.721	.741	.714	.705	.766*	.784*
RM2	PHASE3	277	.832	.679	.689	.575	.547	.685	.674
Mean	Internal	8490		.556	.579	.517	.511	.591**	.592

Notes. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, Hier. G = Hierarchical *g*, P.C. = first principal component.

2. For definitions of schools and criteria, see Tables 12-14.

* p < .05 for the null hypothesis of no difference from the corresponding ASVAB *g*. ** p < .01.

Full-Model Regression Analysis for Each Criterion

Rationale

This section will compare the validities of regression equations based on the ASVAB + ECAT battery with equations based on ASVAB alone to determine how much the addition of ECAT tests can improve validity. The use of optimally-weighted ASVAB tests in regression is controversial. Integer-weighted ASVAB composites have been used operationally in preference to regression equations. In part this is an historical accident, dating from the times of hand calculation. However, regression equations may involve negative weights, penalizing high test scores, and may not cross-validate as well as simpler weighting schemes on small samples. Some people believe that ECAT tests should be evaluated against the operational composites by comparing the validity of the operational composite with an optimally weighted combination of the ECAT tests and the operational composite. Unfortunately, this method would quickly show that the ASVAB itself has incremental validity over the operational composite. In other words, an "ECAT" test that was merely an alternate form of an existing ASVAB test would appear to have incremental validity, because the operational composite is suboptimal, and does not represent the full predictive power of the ASVAB. We must reject the fallacy of such an approach.

Others have suggested using stepwise regression, so that only the significant ASVAB predictors for a particular criterion are used to establish the restricted model. The problem with this approach is more subtle: the degrees of freedom for significance testing will be incorrect. Stepwise regression capitalizes on chance by selecting the best predictors from a larger pool. Significance tests will be biased unless the number of predictors in the larger pool are used for the degrees of freedom. But in that case, one might as well use all of the predictors to begin with.

It is important to realize that we are recommending and using regression for analysis, not prediction. The best equation for prediction is not the sample regression equation, but some variation on it, perhaps ridge regression, perhaps integer weighted composites. Since the appropriate prediction equation has not yet been determined, cross-validation is premature, and is not covered here. Instead, regression will be used to test hypotheses and estimate population validities of population regression equations from their sample values.

Method

Significance Testing

For each criterion in every school, the multiple correlation was computed using the 10 ASVAB tests as predictors. A second multiple correlation was determined by all 10 ASVAB tests plus 6 additional ECAT predictors: Memory Composite (the sum of z-scores for Mental Counters and Sequential Memory), Spatial Composite (the sum of z-scores of Integrating Details and Assembling Objects), Tracking Composite (the sum of z-scores for One-Hand and Two-Hand Tracking), Figural Reasoning, Target Identification, and Spatial Orientation. The tests in the composites were chosen because a priori inspection of the contents of the tests suggested that each pair in a composite was measuring the same construct. Moreover, each test in a pair correlates higher with the other test than it does with any other test, as shown in Tables B-1 and B-2 of Appendix B. For each criterion, the probability associated with the difference was determined from the F-distribution with degrees of freedom equal to 6 and N – (10 + 6) – 1, where

$$F_{6,N-17} = \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}} \bullet \frac{N-17}{6}$$

The composites were used instead of the nine ECAT individual tests in order to decrease the degrees of freedom in the numerator and thus increase the statistical power of the F-test.

Correction for Range Restriction

Next, the correlation matrix of predictors and criterion was corrected for multivariate range-restriction, using a two stage process. First, the uncorrected matrix of 10 ASVAB tests and 9 ECAT tests was obtained for the sample of 10,963 subjects in the ECAT sample. This matrix was corrected for range restriction using the 10 ASVAB variables as explicitly selected variables with population covariances equal to those of the 1991 joint-services applicant population (N = 650,278). The population matrix is shown in Table A-1 of Appendix A.

The corrected 19×19 matrix (Table 4) was treated as if it were the population. The correlation matrix of ASVAB and ECAT tests and a school criterion was then corrected for range restriction as if all 19 tests were explicitly selected. This method has the advantage of having a common, shared matrix of predictor covariances among schools.

After correcting the correlation matrix, the multiple correlations were recomputed for the 10-predictor and 16-predictor models.

Estimating the Population Multiple R^2

The sample multiple correlations were "shrunken" to produce unbiased estimates of the population R^2 using the Wherry formula. However, negative estimates of R^2 were replaced by zero, which re-introduced some bias. Finally, shrunken multiple correlations were generated by taking the square roots of the shrunken R^2.

Correction for Criterion Unreliability

The shrunken range-corrected correlations were divided by the square roots of the range-corrected criterion reliabilities to produce the "fully corrected" multiple correlations. The incremental validities were the differences between fully corrected multiple correlations for the ASVAB-only and ASVAB + ECAT regression models. The "percent increase" was defined as 100 times the validity increment divided by the fully-corrected ASVAB multiple correlation. Where the fully-corrected ASVAB validity was zero, the percent increase was undefined.

Combining Results Across Samples

Using one criterion per school, the results were combined across samples for the School Grade criterion set. Another analysis was done for the set of Internal School Criteria.

The combined probability is given by the chi-square distribution of $\sum_{i=1}^{Schools}(-2\log P_i)$ with $2 \times Schools$ degrees of freedom (Fisher, 1932). The degrees of freedom are 36 for the School Grade set and 38 for the Internal School Criteria Validities, where the Air Traffic Control school was split into two groups.

Mean validities were weighted averages of the multiple correlations for each school, weighted by their degrees of freedom, $N - p - 1$, where p = the number of predictors in the regression equation

Weighting by degrees of freedom is contrary to the method advocated by Hedges, Becker and Wolfe (1992), who recommend weighting each correlation by the inverse of its asymptotic variance. However, two anomalies were observed when using the variances for weighting the multiple R's.

1. For a subsample of ECAT, the mean of the uncorrected full model multiple R's was .956, even though 17 of the 19 schools had multiple R's below .67. It turned out that performance criteria for two schools, AC and ET, had only 19 cases with 16 predictors in the full model, leaving multiple R's of .995 and .983 respectively. These inflated multiple R's produced variance estimates of .000007 and .000076 respectively. The low variances resulted in huge weights for these schools when averaging took place. Although one can argue that the correct "fix" would be to throw out schools with such small samples, this experience suggests that variance weighting may distort the averages obtained when even one multiple R is inflated.

2. Hedges, Becker, and Wolfe recommend that the variance of the range-corrected multiple R_c be estimated by multiplying the variance of the uncorrected R_u by the factor c^2, where $c = \frac{R_c}{R_u}$. For the AO school practical criterion (N = 132), the simple validity of Two-Hand Tracking was -.00896, corrected to .00027. The obtained value of c was 0.0300, resulting in an estimate of the variance of the corrected R of .000009 and a weight of 111,790 for averaging purposes. The resulting mean validity of Two-Hand Tracking was -.004, even though several large schools had validities greater than .30 in absolute value.

Based on these experiences, weighting multiple correlations by their degrees of freedom appears to be the safest method of averaging multiple correlations.

Results

Incremental Validities of ECAT Tests

Incremental validities for all Army, Air Force, and Navy criteria are presented in Tables I-1, I-2, and I-3 of Appendix I. The incremental validities for School Grade criteria appear below in Table 18. Table 19 presents the results for the Internal School Criteria.

The combined probability values are less than 1.4×10^{-17} for all sets of criteria, indicating the overall findings are highly significant. The mean corrected validity increase was .015 for School Grades and .031 for the Internal criteria. However, the Grades criteria actually included the EVTSUM performance criteria for the Army's 11H school, which showed very large validity increments. Seven of the 13 Navy schools showed no significant validity increment in Grades, and nine Navy schools showed no significant increment for the Internal School criteria. Where the criteria exhibited significant validity increments, they were often quite large, but their effects were diluted when averaged with zero-effect criteria.

Table 20 compares the summary results for pure FSG criteria with those for pure practical performance measures. The mean validity gain for predicting FSG is 1.7%, while the gain for predicting performance measures is 5.7%. These findings are consistent with those reported by Wolfe and Alderton (1992) and Wolfe, Alderton, and Larson (1993) for a related battery administered to recruits for nine Navy schools. The mean incremental validity for predicting FSG is about the same as those reported for Project A Core Technical Proficiency by McHenry, Hough, Toquam, Hanson, and Ashworth (1990), but the validity reported for the ASVAB was only .63 in their study.

The mean validity increments are quite substantial, particularly for the performance criteria. If these means were representative of all military training schools, they would provide strong evidence for the utility of enhancing the ASVAB with new tests.

For both FSG and Internal Criteria, all but one of the Air Force and Army schools had above-average validity increments, while 10-11 out of 13 Navy schools were below average. The best Army results were in the 11H Heavy Antiarmor Weapons simulator training performance, where the validity increase was 0.24 correlation points. In the Air Force, both Air Traffic Controller and Personnel Specialist showed validity gains, but the increments were about four times greater for performance criteria (as large as 0.10 for ATC Basic Approach Control Operations). In the Navy, the largest significant validity improvement was 0.031 for Operations Specialist performance. The large nonsignificant .149 validity increase for Navy Air Traffic Control performance should be noted, since it is consistent with the large and significant improvements in predicting Air Force Air Traffic Control Performance.

Incremental Validities of Ability Factors

In order to guard against overestimating incremental validity by underestimating the predictive validity of the ASVAB, it has been necessary to represent the ASVAB by using all 10 of its subtests as predictors in the regression equations. Nevertheless, many of the results are more interpretable in terms of ability factors, rather than individual tests. Therefore, the entire analysis was repeated, using a 4-factor score representation of the ASVAB and a 3-factor representation of the ECAT battery. Each criterion was first fit to a regression equation with the four ASVAB factor scores as independent variables. Then three ECAT factor scores were added, making a 7-predictor regression equation. The results for each school were remarkably similar to those reported in Table 18, Table 19, and Table 20. The mean incremental validities are shown in Table 21, and should be compared with the bottom lines of Table 18, Table 19, and Table 20 (See Appendix J for further details on factor validities.) Although the validities are slightly less for factor scores, the incremental validities are about the same, except for Performance criteria, which show larger gains with the factor score representation.

Figure 10 conveniently summarizes the incremental validities obtained from different forms of predictor representation. It is immediately clear that the incremental validity is about the same, whether in terms of tests, factors, or Hierarchical ***g***. This suggests that the validity improvement from ECAT is due to a better sampling of the tests comprising ***g***. However, the same figure also shows that ***g*** misses more predictive validity than ECAT adds, that is, the validity of enhanced ***g*** is less than the validity of the four ASVAB factors combined into a multiple regression equation. Thus, using ***g*** for prediction wastes a significant part of the ASVAB's validity, contrary to the point of view expressed by Ree and Earles (1991). On the other hand, basing prediction on factor scores is nearly as effective as using individual tests, and may be an excellent way of reducing the errors associated with using too many predictors in regression, while retaining the potential for differential prediction.

Table 18

ECAT Incremental Validities for School Grades

School	Criterion	Sample Size	Uncorrected Multiple R: ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{6,N-17}$	Corrected Multiple R: ASVAB	Increase	Percent Increase
11H(A)5	EVTSUM	546	.321	.373	4.119	1.53×10^{-3}	.392	.036	9.2 **
11H(B)5	EVTSUM	316	.330	.446	11.216	1.64×10^{-5}	.382	.091	23.7 **
13F1	FSG	821	.544	.597	9.483	9.81×10^{-14}	.790	.024	3.0 **
APS1	FSG	446	.545	.581	6.233	2.17×10^{-4}	.828	.012	1.5 **
ATC1	FSG	484	.403	.445	4.540	1.98×10^{-3}	.727	.020	2.7 **
AC1	FSG	72	.627	.649	4.978	8.37×10^{-1}	.839	.000	0.0
AE1	FSG	278	.489	.542	7.810	3.04×10^{-3}	.659	.023	3.5 **
AMS1	FSG	244	.599	.602	.555	9.73×10^{-1}	.848	.000	0.0
AO1	FSG	234	.504	.522	2.434	5.10×10^{-1}	.717	.005	0.7
AV1	FSG	544	.517	.536	2.772	2.49×10^{-2}	.810	.005	0.7 *
EM1	FSG	797	.451	.459	.864	3.47×10^{-1}	.687	.000	0.0
EN 1	FSG	750	.584	.588	.721	5.09×10^{-1}	.763	.000	0.0
ET2	FSG2	86	.504	.566	9.738	3.60×10^{-1}	.813	.027	3.3
FC1	FSG	778	.499	.528	4.180	2.28×10^{-5}	.828	.010	1.2 **
GM1	FSG	420	.428	.454	2.911	7.10×10^{-2}	.731	.004	0.6
MM1	FSG	801	.402	.425	2.362	5.41×10^{-3}	.557	.012	2.2 **
OS1	FSG	713	.565	.582	2.969	2.33×10^{-3}	.804	.007	0.9 **
RM1	FSG	277	.536	.587	8.796	1.17×10^{-3}	.775	.022	2.8 **
Summary	Grades	8607	.467[a]	.510	4.194[b]	$<1.4\times10^{-17}$ [c]	.713	.015	2.0[d] **

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

[a]Mean multiple Rs are means of Wherry-shrunken Rs.

[b]Percent Variance = $100\times\dfrac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}$

[c]Summary probability = $P(\chi^2_{36})$.

[d]The summary percent increase is defined as 100 × the ratio of the mean increase to the mean corrected ASVAB validity.

* p < .05 for uncorrected R increase. ** p < .01 for uncorrected R increase.

Table 19

ECAT Incremental Validities for Internal School Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{6,N-17}$	ASVAB	Increase	Percent Increase
11H(A)6	TO_1	542	.210	.269	3.031	1.52×10^{-2}	.240	.046	19.1 *
11H(B)9	ITVTOW	318	.154	.350	11.203	1.51×10^{-5}	.075	.237	316.3 **
13F3	FIRIN G	821	.444	.466	2.507	2.82×10^{-3}	.730	.007	1.0 **
APS3	AFPT70	432	.294	.404	9.129	2.28×10^{-6}	.388	.079	20.4 **
ATC(A)4	BLK5A	205	.322	.404	7.127	4.18×10^{-2}	.614	.079	12.9 *
ATC(B)4	BLK5A	295	.312	.408	8.316	1.04×10^{-3}	.450	.100	22.2 **
AC2	PERF	76	.330	.460	13.033	2.80×10^{-1}	.381	.149	39.2
AE2	SUM2	273	.440	.487	5.808	2.39×10^{-2}	.608	.022	3.7 *
AMS2	PERF	244	.393	.431	3.892	1.89×10^{-1}	.650	.016	2.4
AO2	PRACTL	229	.343	.374	2.652	4.69×10^{-1}	.490	.010	2.1
AV4	PERFORM	352	.379	.409	2.853	1.48×10^{-1}	.673	.016	2.4
EM2	PHASE1	797	.474	.482	.950	2.86×10^{-1}	.729	.001	0.1
EN 1	FSG	750	.584	.588	.721	5.09×10^{-1}	.763	.000	0.0
ET3	PERF	86	.482	.574	14.533	1.41×10^{-1}	.735	.075	10.2
FC2	RADAR	780	.345	.381	3.053	7.93×10^{-4}	.733	.016	2.1 **
GM3	HALF2	397	.458	.467	1.033	6.87×10^{-1}	.734	.000	0.0
MM1	FSG	801	.402	.425	2.362	5.41×10^{-3}	.557	.012	2.2 **
OS3	PERF	815	.523	.564	6.510	3.81×10^{-9}	.791	.025	3.1 **
RM2	PHASE3	277	.420	.464	4.907	5.08×10^{-2}	.702	.017	2.4
Summary	Internal	8490	.373[a]	.440	3.966[b]	$< 1.4\times10^{-17}$ [c]	.619	.031	5.0d **

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

[a]Mean multiple Rs are means of Wherry-shrunken Rs.

[b]Percent Variance = $100\times\dfrac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}$

[c]Summary probability = $P(\chi^2_{38})$.

[d]The summary percent increase is defined as 100 × the ratio of the mean increase to the mean corrected ASVAB validity.

* p < .05 for uncorrected R increase. ** p < .01 for uncorrected R increase.

Table 20

Comparison of FSG and Performance Criteria for 10 Schools With Both Criteria

		Uncorrected Multiple R				Corrected Multiple R		
Criterion Set	Sample Size	ASVAB[a]	ASVAB +ECAT	Percent Variance[b]	Probability[c] of $F_{6,N-17}$	ASVAB	ECAT Increase	Percent Increase
FSG	3922	0.505	0.551	5.219	4.163×10^{-17}	0.783	0.013	1.7 *
Performance	3828	0.373	0.453	5.578	2.442×10^{-15}	0.638	0.036	5.7 *

Notes. FSG = Final School Grade, ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

[a]Mean multiple Rs are means of Wherry-shrunken Rs.

[b]Percent Variance = $100\times\dfrac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}$

[c]Summary probability = $P(X^2_{20})$ for FSG and $P(X^2_{22})$ for Performance.

* $p < 10^{-14}$ for uncorrected R increase.

Table 21

Incremental Validities of 3 ECAT Factor Scores Over 4 ASVAB Factor Scores

		Uncorrected Multiple R			Corrected Multiple R		
Criterion Set	Sample Size	ASVAB[a]	ASVAB +ECAT	Percent Variance[b]	ASVAB	ECAT Increase	Percent Increase[c]
Internal	8490	.342	.413	3.370	.608	.031	5.1 *
Grades	8607	.447	.488	3.325	.708	.013	1.9 *
Performance	3828	.328	.424	5.374	.620	.041	6.6 *
FSG	3922	.487	.534	4.838	.778	.014	1.9 *

Notes. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

[a]Mean multiple Rs are means of Wherry-shrunken Rs.

[b]Percent Variance = Mean of $100\times\dfrac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}$

[c]Summary probability = $P(X^2_{36})$ for Grades, $P(X^2_{38})$ for Internal Criteria, $P(X^2_{20})$ for FSG, and $P(X^2_{22})$ for Performance, where $X^2_{2\times Schools} = \sum_{k=1}^{Schools} -2\log(P(F_{3,N_k-8}))$.

* $p < 1.4\times10^{-17}$ for uncorrected R increase.

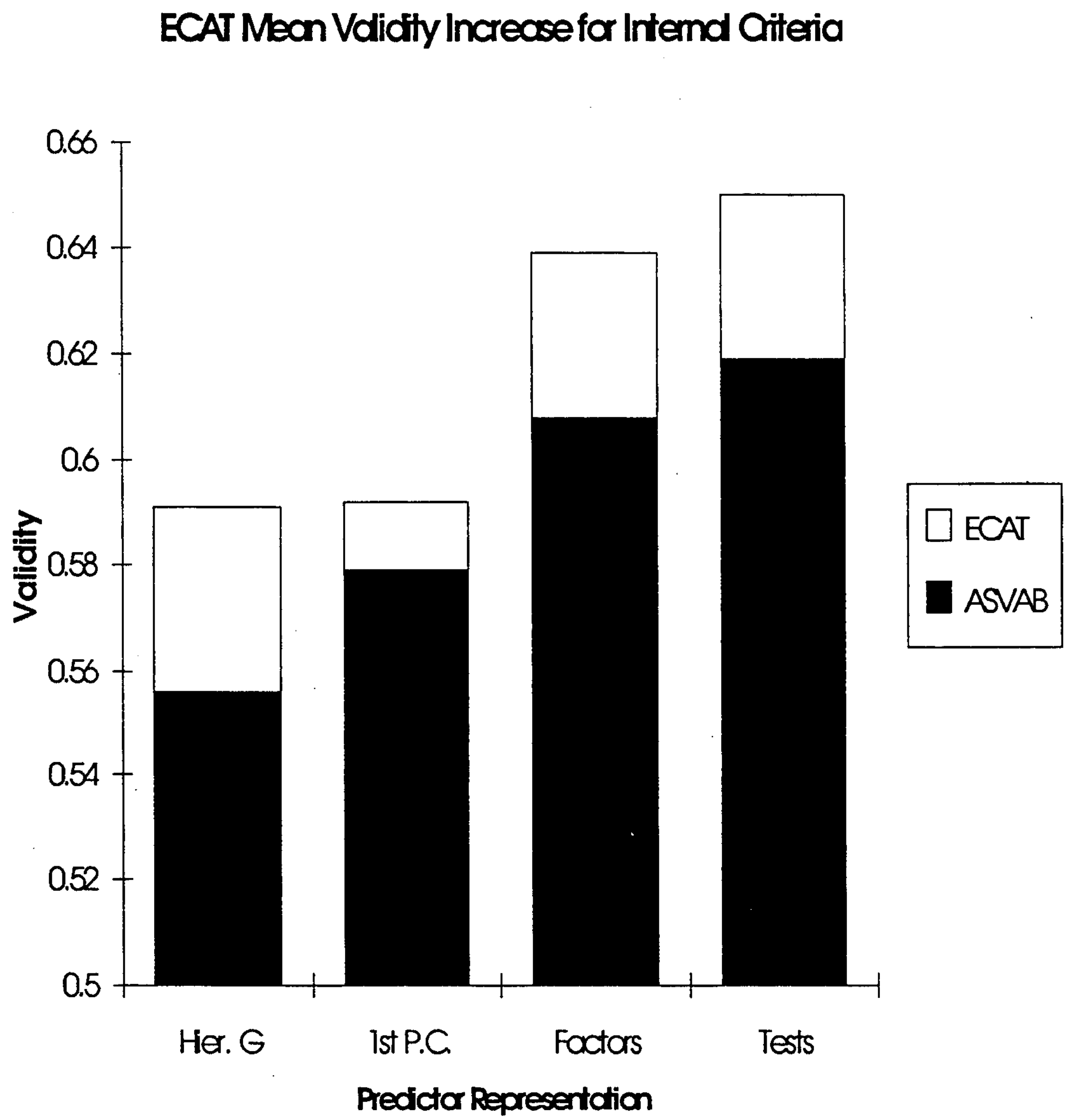


Figure 10. ASVAB validities and ECAT validity increases for different predictor representations.

Regression Analyses for Each Predictor's Incremental Validity

Method

Significance

For each criterion in each school and each predictor, two hypotheses were tested:

1. Adding just this one predictor to the ASVAB does not significantly increase the multiple R:

$$\Delta R^2 = R^2{}_{ASVAB+1} - R^2{}_{ASVAB} \ .$$

$$F_{1,N-12} = (N-12)\frac{\Delta R^2}{1-R^2{}_{ASVAB+1}}.$$

2. Deleting just this one predictor from the full battery of ASVAB plus ECAT does not significantly decrease the multiple R:

The general approach was to examine the validity of composites first; if significant, then the component tests in a composite were examined for significance. When it was necessary to split a composite up into its components, then the remaining composites were also split. Thus, if the predictor was a test that was also part of a composite, then the battery of ASVAB plus nine individual tests was compared with the same battery with the one test deleted; otherwise, the full battery consisting of ASVAB plus three composites plus three tests was compared with the same battery with the one predictor deleted. For example, the effect of deleting One-Hand tracking was tested by comparing the multiple R of ASVAB plus nine ECAT predictors with the Multiple R of ASVAB plus eight ECAT predictors.

$$\Delta R^2 = R^2{}_{ASVAB+9ECAT} - R^2{}_{ASVAB+8ECAT} \ .$$

$$F_{1,N-20} = (N-20)\frac{\Delta R^2}{1-R^2{}_{ASVAB+9ECAT}}.$$

The effect of deleting Target Identification was tested by comparing the Multiple R of ASVAB plus six ECAT predictors with the Multiple R of ASVAB plus five ECAT predictors.

$$\Delta R^2 = R^2{}_{ASVAB+6ECAT} - R^2{}_{ASVAB+5ECAT} \ .$$

$$F_{1,N-17} = (N-17)\frac{\Delta R^2}{1-R^2{}_{ASVAB+6ECAT}}.$$

Corrected Multiple Correlations and Increments

After significance testing, all correlations were corrected for multivariate range restriction, shrunken to their population values (Wherry), and corrected for criterion unreliability.

Combining Results Across Samples

For the two subset of criteria (School Grades and Internal School Criteria), the Fisher chi-square method was used to combine probabilities. Mean validities were computed by weighting each multiple correlation by its degrees of freedom.

For the nine schools that had both FSG and practical performance criteria available, comparative summaries were prepared combining results across samples.

Display of Selected Test × Criterion Results

In order to reduce the Type I error associated with multiple significance tests, incremental validities for individual predictors were displayed only for criteria that proved significant in the full-model regression comparing ASVAB with ASVAB plus six ECAT predictors.

Results

Combined Results Across Samples

Table 22 and Table 23 show the mean incremental validities and combined probabilities for each ECAT predictor for the School Grade criteria and the Internal School Criteria. The two tables are remarkably consistent with one another. In both tables, the accretion probabilities show that every ECAT predictor (except for Target Identification in Table 23) significantly increases the validity of ASVAB by itself.

The deletion probability is a measure of redundancy with other ECAT tests. From both Table 22 and Table 23, it is clear that either Integrating Details or Assembling Objects can be deleted without significant decrease in validity, but not both, because the Spatial Composite cannot be deleted. On the other hand, neither working memory test and neither tracking test can be deleted without significant decrease in validity.[4] Spatial Orientation can be deleted.

The mean increments or decrements from a single test are small. All ECAT tests show validity increments in some schools that are much larger than their means, as will be shown in the next section.

---

[4]These findings for the spatial ability tests and working memory tests confirm those of Wolfe, Alderton, and Larson (1993) for nine Navy schools.

Table 22

Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB for 18 School Grade Criteria (N = 8607)

Predictor	Simple Validity	$R_{ASVAB+1}$	Validity Increase	$P(X^2_{36})$ for Accretion	$R_{ASVAB+ECAT-1}$	Validity Decrease	$P(X^2_{36})$ for Deletion
Mental Counters	.451	.718	.005	4.86×10^{-16}	.728	.001	.007
Sequential Memory	.410	.717	.004	1.84×10^{-10}	.728	.001	.011
Integrating Details	.498	.717	.004	5.46×10^{-12}	.729	.001	.178
Assembling Objects	.474	.718	.005	1.47×10^{-12}	.728	.001	.089
One-Hand Tracking	-.301	.718	.005	1.97×10^{-8}	.728	.001	.039
Two-Hand Tracking	-.339	.719	.006	1.43×10^{-8}	.728	.002	.011
Target Identification	-.257	.716	.003	5.76×10^{-5}	.726	.001	.006
Spatial Orientation	.475	.717	.004	6.98×10^{-10}	.727	.001	.302
Figural Reasoning	.499	.717	.004	6.12×10^{-12}	.726	.001	.003
Memory Composite	.477	.719	.006	$<1.4\times10^{-17}$	.726	.002	.000
Spatial Composite	.535	.719	.006	$<1.4\times10^{-17}$	.726	.001	.016
Tracking Composite	-.342	.719	.006	4.48×10^{-10}	.725	.003	.006
Memory Factor	.492	.714	.006	$<1.4\times10^{-17}$	.720	.001	.010
Space Factor	.590	.717	.009	1.39×10^{-17}	.718	.003	.000
Psychomotor Factor	-.378	.714	.007	9.20×10^{-12}	.717	.003	.001

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 23

Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB for 19 Internal School Criteria (N = 8490)

Predictor	Simple Validity	$R_{ASVAB+1}$	Validity Increase	$P(X^2_{38})$ for Accretion	$R_{ASVAB+ECAT-1}$	Validity Decrease	$P(X^2_{38})$ for Deletion
Mental Counters	.393	.628	.009	2.37×10^{-11}	.650	.003	.010
Sequential Memory	.354	.626	.007	1.18×10^{-9}	.650	.003	.001
Integrating Details	.427	.624	.005	4.45×10^{-6}	.653	.001	.848
Assembling Objects	.418	.627	.009	1.57×10^{-9}	.651	.002	.155
One-Hand Tracking	-.289	.633	.015	1.71×10^{-9}	.650	.003	.016
Two-Hand Tracking	-.301	.632	.014	5.93×10^{-9}	.649	.004	.001
Target Identification	-.223	.620	.002	6.32×10^{-2}	.650	.002	.136
Spatial Orientation	.411	.625	.006	1.21×10^{-5}	.650	.001	.300
Figural Reasoning	.438	.626	.007	7.12×10^{-9}	.649	.002	.049
Memory Composite	.414	.630	.011	1.54×10^{-14}	.645	.006	.000
Spatial Composite	.465	.629	.010	6.34×10^{-12}	.649	.002	.039
Tracking Composite	-.315	.635	.016	1.25×10^{-10}	.639	.012	.000
Memory Factor	.427	.622	.013	$<1.4\times10^{-17}$	.637	.004	.000
Space Factor	.514	.625	.016	$<1.4\times10^{-17}$	.637	.004	.000
Psychomotor Factor	-.344	.626	.016	5.68×10^{-12}	.630	.011	.000

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 24 and Table 25 show the similar results for the 10 schools that had both FSG and Performance criteria available. The results are somewhat different from the summaries across all 18 schools. For the FSG criteria, only three predictors cannot be deleted without significant loss: the Memory composite and the Memory and Space Factors. Either Mental Counters or Sequential Memory could be deleted, but not both.

The performance criteria for the same 10 schools show much larger incremental validities and more significant effects. In Table 25, the Memory and Tracking composites plus Sequential memory and both tracking tests have unique predictive power, as shown by their significant deletion probabilities. The strong showing for the psychomotor tests is impressive, considering that the sample did not include the Army's 11H school, which showed extremely large validity increments. In addition, the same significant finding for the Memory composite that was observed for the FSG criteria also applies to the performance criteria.

Table 24

Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB for Final School Grade Criteria of 10 Schools With Dual Criteria (N = 3922)

Predictor	Simple Validity	$R_{ASVAB+1}$	Validity Increase	$P(X^2_{20})$ for Accretion	$R_{ASVAB+ECAT-1}$	Validity Decrease	$P(X^2_{20})$ for Deletion
Mental Counters	.520	.791	.007	9.54×10^{-14}	.795	.002	.071
Sequential Memory	.489	.789	.006	2.39×10^{-11}	.796	.001	.109
Integrating Details	.550	.789	.005	2.59×10^{-10}	.796	.001	.253
Assembling Objects	.523	.788	.005	5.62×10^{-9}	.797	.000	.847
One-Hand Tracking	-.325	.786	.003	1.93×10^{-4}	.796	.001	.128
Two-Hand Tracking	-.362	.785	.002	3.01×10^{-3}	.797	.000	.387
Target Identification	-.299	.785	.002	5.36×10^{-2}	.796	.001	.705
Spatial Orientation	.529	.788	.004	5.97×10^{-9}	.796	.001	.325
Figural Reasoning	.559	.788	.005	1.34×10^{-10}	.796	.001	.076
Memory Composite	.559	.792	.009	$<1.4\times10^{-17}$	.794	.002	.000
Spatial Composite	.591	.791	.008	1.19×10^{-14}	.796	.001	.210
Tracking Composite	-.367	.786	.003	1.78×10^{-4}	.796	.000	.420
Memory Factor	.575	.788	.010	$<1.4\times10^{-17}$	.790	.001	.011
Space Factor	.659	.790	.013	1.75×10^{-11}	.789	.003	.000
Psychomotor Factor	-.408	.780	.003	2.05×10^{-5}	.792	.001	.339

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 25

Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB for Performance Criteria of 10 Schools With Dual Criteria (N = 3828)

Predictor	Simple Validity	$R_{ASVAB+1}$	Validity Increase	$P(X^2_{22})$ for Accretion	$R_{ASVAB+ECAT-1}$	Validity Decrease	$P(X^2_{22})$ for Deletion
Mental Counters	.466	.657	.019	8.18×10^{-12}	.675	.005	.057
Sequential Memory	.441	.653	.015	5.70×10^{-11}	.675	.004	.030
Integrating Details	.459	.648	.010	3.74×10^{-6}	.679	.001	.767
Assembling Objects	.449	.650	.012	1.96×10^{-8}	.678	.001	.525
One-Hand Tracking	-.309	.651	.013	4.41×10^{-7}	.675	.004	.018
Two-Hand Tracking	-.301	.647	.010	5.21×10^{-6}	.674	.005	.008
Target Identification	-.252	.642	.004	4.17×10^{-2}	.674	.002	.313
Spatial Orientation	.435	.646	.008	1.21×10^{-5}	.675	.001	.360
Figural Reasoning	.469	.650	.012	4.99×10^{-7}	.674	.001	.641
Memory Composite	.502	.661	.023	3.33×10^{-16}	.668	.007	.000
Spatial Composite	.501	.654	.016	4.25×10^{-11}	.673	.002	.135
Tracking Composite	-.326	.650	.013	2.66×10^{-7}	.668	.007	.000
Memory Factor	.513	.649	.028	$< 1.4\times10^{-17}$	.659	.004	.001
Space Factor	.559	.652	.030	$< 1.4\times10^{-17}$	.658	.005	.000
Psychomotor Factor	-.358	.635	.014	2.04×10^{-8}	.656	.008	.000

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Test × Criterion Results

Validity increments for adding just one new predictor to the ASVAB are shown for each predictor and each significant criterion in Table 26 and Table 28 for the School Grade criteria and in Table 27 and Table 29 for the Internal School criteria. (Table I-4 of Appendix I gives the results for all significant criteria for all schools.)

There are a large number of significant findings shown in the tables. We mention below those significant incremental validities greater than .02. Values larger than .04 are listed in parentheses. This does not imply that the lesser values are not important, however.

Memory Factor: 11H(B) EVTSUM, AE FSG, APS typing speed (AFPT70) (.05), ATC Basic Approach Control Operations (.09 and .06), Navy AC performance (.15), AE performance (SUM2), and OS performance.

Psychomotor Factor: 11H all criteria (as high as .178), ATC Basic Approach Control Operations (.05).

Table 26

Incremental Validities From Adding one ECAT Factor to Four ASVAB Factors for Significant School Grades From Full Model

School	Criterion	Memory	Psychomotor	Space
11H(A)5	EVTSUM	.012*	.034**	.027**
11H(B)5	EVTSUM	.021**	.086**	.023**
13F1	FSG	.018**	.007**	.028**
APS1	FSG	.009**	.000	.006**
ATC1	FSG	.012**	.006*	.013**
AC1	FSG	.000	.000	.000
AE1	FSG	.024**	.003*	.022**
AV1	FSG	.005**	.001	.004**
FC1	FSG	.000	.000	.003**
MM1	FSG	.000	.000	.006**
OS1	FSG	.007**	.000	.008**
RM1	FSG	.005*	.001	.004

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.
2. For definitions of schools and criteria, see Tables 12–14.
* p < .05 for uncorrected R increase. ** p < .01 for uncorrected R increase.

Table 27

Incremental Validities From Adding one ECAT Factor to Four ASVAB Factors for Significant Internal Criteria From Full Model

School	Criterion	Memory	Psychomotor	Space
11H(A)6	TO_1	.000	.055**	.003
11H(B)9	ITVTOW	.000	.178**	.039**
13F3	FIRING	.011**	.005**	.009**
APS3	AFPT70	.051**	.015*	.034**
ATC(A)4	BLK5A	.089*	.047*	.120**
ATC(B)4	BLK5A	.060**	.053**	.078**
AC2	PERF	.150*	.019	.142
AE2	SUM2	.024**	.000	.013**
AV4	PERFORM	.009	.014*	.011*
FC2	RADAR	.002*	.004	.000
MM1	FSG	.000	.000	.006**
OS3	PERF	.020**	.008**	.025**

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.
2. For definitions of schools and criteria, see Tables 12–14.
* p < .05 for uncorrected R increase. ** p < .01 for uncorrected R increase.

Table 28

Incremental Validities From Adding one ECAT Test to the ASVAB for Significant School Grade Criteria

School	Criterion	Mental Counters	Sequential Memory	Integrating Details	Assembling Objects
11H(A)5	EVTSUM	.013*	.008	.004	.027**
11H(B)5	EVTSUM	.008	.024*	.016*	.003
13F1	FSG	.010**	.009**	.012**	.012**
APS1	FSG	.002	.006**	.003*	.000
ATC1	FSG	.015**	.004	.001	.005*
AE1	FSG	.010**	.020**	.019**	.009*
AV1	FSG	.007**	.002*	.002*	.002*
FC1	FSG	.000	.000	.001	.003**
MM1	FSG	.000	.000	.003	.009**
OS1	FSG	.007**	.003*	.002*	.002*
RM1	FSG	.004	.002	.004	.000

School	Criterion	One-Hand Tracking	Two-Hand Tracking	Target Identification	Spatial Orientation
11H(A)5	EVTSUM	.019**	.029**	.011*	.010*
11H(B)5	EVTSUM	.059**	.078**	.021*	.022**
13F1	FSG	.005**	.003**	.003*	.010**
APS1	FSG	.000	.000	.000	.002*
ATC1	FSG	.006*	.003	.008**	.010**
AE1	FSG	.004*	.000	.004	.004*
AV1	FSG	.000	.002	.000	.001
FC1	FSG	.000	.001*	.001*	.000
MM1	FSG	.003*	.000	.000	.000
OS1	FSG	.000	.001	.000	.003*
RM1	FSG	.002	.000	.011**	.002

School	Criterion	Memory Composite	Spatial Composite	Tracking Composite	Figural Reasoning
11H(A)5	EVTSUM	.015*	.020**	.028**	.000
11H(B)5	EVTSUM	.023*	.013	.080**	.001
13F1	FSG	.013**	.017**	.005**	.000
APS1	FSG	.006**	.002*	.000	.010**
ATC1	FSG	.013**	.004*	.005*	.010**
AE1	FSG	.021**	.020**	.003*	.002
AV1	FSG	.007**	.003*	.001	.001
FC1	FSG	.000	.003**	.000	.015
MM1	FSG	.000	.008**	.000	.002*
OS1	FSG	.007**	.003**	.000	.009**
RM1	FSG	.005	.002	.002	.004**

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.
2. For definitions of schools and criteria, see Tables 12–14.
* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 29

Incremental Validities From Adding one ECAT Test to the ASVAB for Significant Internal School Criteria

School	Criterion	Mental Counters	Sequential Memory	Integrating Details	Assembling Objects
11H(A)6	TO_1	.000	.000	.000	.000
11H(B)9	ITVTOW	.000	.000	.006	.056*
13F3	FIRING	.002*	.007**	.002*	.002*
APS3	AFPT70	.018**	.034**	.025**	.010*
ATC(A)4	BLK5A	.111**	.006	.026*	.015
ATC(B)4	BLK5A	.060*	.032	.014	.040*
AC2	PERF	.048	.135*	.045	.126*
AE2	SUM2	.008*	.018**	.005	.004
FC2	RADAR	.000	.005**	.000	.001
MM1	FSG	.000	.000	.003	.009**
OS3	PERF	.017**	.011**	.006**	.010**
RM2	PHASE3	.004	.000	.002	.000
School	Criterion	One-Hand Tracking	Two-Hand Tracking	Target Identification	Spatial Orientation
11H(A)6	TO_1	.036**	.044**	.000	.008
11H(B)9	ITVTOW	.159**	.172**	.000	.047*
13F3	FIRING	.006**	.002*	.002	.002*
APS3	AFPT70	.006	.028**	.000	.004
ATC(A)4	BLK5A	.030	.015	.005	.000
ATC(B)4	BLK5A	.049**	.034**	.023*	.044**
AC2	PERF	.063	.000	.000	.033
AE2	SUM2	.000	.000	.009*	.000
FC2	RADAR	.002	.004*	.000	.000
MM1	FSG	.003*	.000	.000	.000
OS3	PERF	.003*	.006**	.000	.011**
RM2	PHASE3	.000	.000	.006	.006
School	Criterion	Memory Composite	Spatial Composite	Tracking Composite	Figural Reasoning
11H(A)6	TO_1	.000	.000	.047**	.007
11H(B)9	ITVTOW	.004	.047**	.185**	.000
13F3	FIRING	.006**	.003**	.005**	.003**
APS3	AFPT70	.036**	.024**	.018**	.014**
ATC(A)4	BLK5A	.066**	.031**	.027	.060**
ATC(B)4	BLK5A	.063*	.038*	.049**	.036
AC2	PERF	.128	.123	.025	.070
AE2	SUM2	.019**	.007	.000	.003
FC2	RADAR	.003*	.000	.004*	.003
MM1	FSG	.000	.008**	.000	.009**
OS3	PERF	.019**	.012**	.005**	.007**
RM2	PHASE3	.003	.002	.000	.000

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12–14.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Space Factor: 11H EVTSUM and ITVTOW. 13F FSG, APS Typing Speed, AE FSG, ATC Basic Approach Control Operations (.12 and .08), and OS performance.

Mental Counters: ATC Basic Approach Control Operations (.11).

Sequential Memory: 11H EVTSUM, Aviation Electrician FSG, APS typing speed, and Navy Air Traffic Control performance (.14).

Integrating Details: APS Typing Speed and ATC Basic Approach Control Operations (.052).

Assembling Objects: 11H TOW Simulator Tracking (ITVTOW .06), ATC Basic Approach Control Operations (.04), and Navy Air Traffic Control performance (.13).

One-Hand Tracking 11H TOW Firing (EVTSUM .06), TOW Simulator Tracking (TO_1 and ITVTOW .16); ATC Basic Approach Control Operations (.05).

Two-Hand Tracking: 11H TOW Firing (EVTSUM .08), TOW Simulator Tracking (TO_1 .04 and ITVTOW .17), APS typing speed, ATC Basic Approach Control Operations.

Target Identification: ATC Basic Approach Control Operations, and 11H TOW Firing EVTSUM.

Spatial Orientation: ATC Basic Approach Control Operations (.04), 11H TOW Firing EVTSUM and ITVTOW.

Figural Reasoning: ATC Basic Approach Control Operations (.06).

It is interesting that Working Memory seems to predict typing speed better than Tracking does (.036 vs. .018).

It is evident that even a single test added to the ASVAB can produce large validity gains for some criteria, with the largest gains exceeding .10 from the two tracking tests, the two memory tests, and Assembling Objects.

Stepwise Meta-analysis

Method

The last section showed the mean validity changes resulting from adding or deleting a single predictor from the battery. This information could be used to select the best predictor to add or delete from the battery in order to maximize validity averaged across samples. Suppose we were to add or delete that predictor, and then re-do the whole analysis in each sample, then average across samples to determine the mean incremental validities of the remaining predictors with respect to the modified battery. Repeat the process in order to determine the next predictor to add or delete. This, in essence, is what we mean by a stepwise meta-analysis.

The algorithm is quite simple. For accretion, select the predictor with the greatest mean incremental validity. Add it to the battery. In each sample, compute the incremental validities of each of the remaining unused predictors with respect to the modified battery. Average across samples to compute the mean incremental validities of each of the remaining unused predictors with respect to the modified battery. Select the predictor with the greatest mean incremental validity, and repeat the procedure until all predictors have entered the battery. For deletion, find the predictor that decreases mean validity the least, delete it from the battery, then compute the mean validity decrements from deleting each of the remaining predictors from the modified battery. Repeat the procedure until all predictors have been removed from the battery.[5]

Appendix K gives a concrete representation of this procedure in the form of a SAS program to carry out both accretion and deletion meta-analyses. All of the results in this section were produced by this program.

Three types of meta-analyses were done.

1. ASVAB Kernel. The first type of analysis assumed that all 10 ASVAB tests remained in regression at all times, and concentrated on adding or deleting only the ECAT variables. Four analyses were done with different subsets of the ECAT variables:

    a. All nine ECAT tests.

    b. Six ECAT tests that did not use the psychomotor response pedestal.

    c. Three P&P ECAT tests only.

    d. Several combinations of three ECAT tests.

---

[5]A similar procedure was independently developed by Abrahams and Alf and used in the ECAT analyses done by Abrahams, Pass, Kusulas, Cole, and Kieckhaefer (1993). Both procedures bear a strong similarity to Horst (1955), who showed how to maximize the mean squared multiple correlation.

These analyses made it possible to determine the incremental value of P&P tests, computerized cognitive tests, and computerized psychomotor tests, respectively.

2. AFQT Kernel. The second type of analysis assumed that only the four AFQT tests (WK, PC, AR, MK) remained in regression at all times, and allowed either an ECAT test or another ASVAB test to enter or exit the regression equations.

3. Null Kernel. The third type of analysis allowed even the AFQT tests to be replaced by ECAT tests if the result were higher multiple correlations.

All analyses used fully corrected mean validities, i.e., range-corrected, then Wherry-shrunken, then corrected for criterion reliability, then averaged by weighting them by their degrees of freedom.

Results

Deletion generally produced multiple correlations equal to or larger than accretion in the range of 10-12 predictors, so only the deletion results are shown.

The three analyses with all nine ECAT tests are presented in Table 30, Table 31, and Table 32. Certain ECAT tests seem to enter regression early: Two-Hand Tracking, Mental Counters, and Assembling Objects. The first ASVAB tests to be displaced are Numerical Operations, Mechanical Comprehension, and General Science.

The *substitutional* validity of the ECAT tests can be determined by comparing the validities for 10-test batteries. From Table 31, line 10, it is easy to see that replacing NO, MC, and GS with Assembling Objects, Two-Hand tracking, and one of the Working Memory tests increases the mean battery validity for predicting School Grades by 1.4% and internal criteria by 3.6%. These gains can be achieved without changing the AFQT or increasing total testing time.

Figure 11 depicts the results from Table 30 and Table 31. When the regression equations start with all 10 ASVAB tests, the validity curve tends to level out after three ECAT tests are entered. These three ECAT tests correspond to the three underlying factors in the ECAT battery: Psychomotor Ability, Working Memory, and Spatial Ability. Three ECAT tests produce 76% of the gain from using the full battery of nine tests for predicting Internal Criteria. The two curves on the left show what happens when the four tests in the AFQT are used as the starting point, and other ASVAB or ECAT tests are free to enter. With seven or eight tests, the curve rises above the validity line for the 10-test ASVAB.

Table 30

Means of Fully Corrected Multiple Correlations for Stepwise Deletion Meta-analysis Assuming 10 ASVAB Tests in Model

Number of	School Grade Criteria		Internal Criteria	
Predictors	Predictor	$\overline{R}$	Predictor	$\overline{R}$
10	10 ASVAB Tests	.714	10 ASVAB Tests	.620
11	+ Two-Hand Tracking	.719	+ Two-Hand Tracking	.633
12	+ Mental Counters	.723	+ Mental Counters	.642
13	+ Assembling Objects	.725	+ Figural Reasoning	.646
14	+ Figural Reasoning	.727	+ One-Hand Tracking	.648
15	+ One-Hand Tracking	.728	+ Sequential Memory	.651
16	+ Sequential Memory	.729	+ Assembling Objects	.652
17	+ Target Identification	.730	+ Target Identification	.653
18	+ Spatial Orientation	.730	+ Spatial Orientation	.654
19	+ Integrating Details	.730	+ Integrating Details	.653

Note. ASVAB = Armed Services Vocational Aptitude Battery.

Table 31

Means of Fully Corrected Multiple Correlations for Stepwise Deletion Meta-analysis Assuming Four AFQT Tests in Model

Number of	School Grade Criteria		Internal Criteria	
Predictors	Predictor	$\overline{R}$	Predictor	$\overline{R}$
4	4 AFQT Tests	.671	4 AFQT Tests	.565
5	+ Auto-Shop Information	.697	+ Auto-Shop Information	.594
6	+ Assembling Objects	.706	+ Two-Hand Tracking	.613
7	+ Two-Hand Tracking	.711	+ Mental Counters	.624
8	+ Coding Speed	.716	+ Coding Speed	.632
9	+ Electronics Information	.721	+ Electronics Information	.638
10	+ Mental Counters	.724	+ Assembling Objects	.642
11	+ Figural Reasoning	.725	+ One-Hand Tracking	.645
12	+ General Science	.726	+ Sequential Memory	.647
13	+ One-Hand Tracking	.727	+ Figural Reasoning	.649
14	+ Sequential Memory	.728	+ General Science	.651
15	+ Target Identification	.729	+ Mechanical Comprehension	.652
16	+ Spatial Orientation	.730	+ Target Identification	.653
17	+ Integrating Details	.730	+ Numerical Operations	.653
18	+ Numerical Operations	.730	+ Spatial Orientation	.654
19	+ Mechanical Comprehension	.730	+ Integrating Details	.653

Note. AFQT = Armed Forces Qualification Test.

Table 32

Means of Fully Corrected Multiple Correlations for Stepwise Deletion Meta-analysis With or Without ASVAB Tests in Model

Number of	School Grade Criteria		Internal Criteria	
Predictors	Predictor	$\overline{R}$	Predictor	$\overline{R}$
1	Mathematics Knowledge	.563	Arithmetic Reasoning	.517
2	+ Auto-Shop Information	.648	+ Auto-Shop Information	.553
3	+ Arithmetic Reasoning	.679	+ Mathematics Knowledge	.582
4	+ Paragraph Comprehension	.694	+ Two-Hand Tracking	.601
5	+ Assembling Objects	.703	+ Coding Speed	.614
6	+ Electronics Information	.709	+ Mental Counters	.624
7	+ Coding Speed	.715	+ Electronics Information	.631
8	+ Two-Hand Tracking	.719	+ Paragraph Comprehension	.636
9	+ Mental Counters	.722	+ Assembling Objects	.639
10	+ Word Knowledge	.724	+ One-Hand Tracking	.642
11	+ Figural Reasoning	.725	+ Word Knowledge	.645
12	+ General Science	.726	+ Sequential Memory	.647
13	+ One-Hand Tracking	.727	+ Figural Reasoning	.649
14	+ Sequential Memory	.728	+ General Science	.651
15	+ Target Identification	.729	+ Mechanical Comprehension	.652
16	+ Spatial Orientation	.730	+ Target Identification	.653
17	+ Integrating Details	.730	+ Numerical Operations	.653
18	+ Numerical Operations	.730	+ Spatial Orientation	.654
19	+ Mechanical Comprehension	.730	+ Integrating Details	.653

Note. ASVAB = Armed Services Vocational Aptitude Battery.

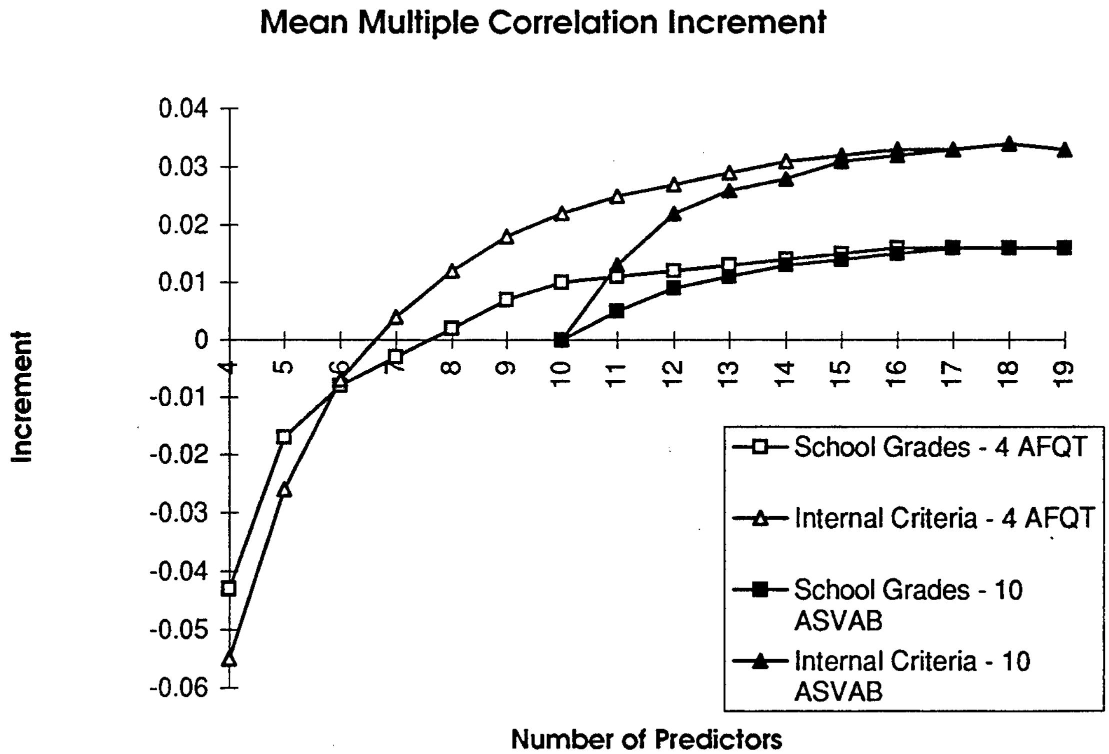


Figure 11. Incremental validity as a function of number of ECAT tests.

In all three analyses, the same three ECAT tests emerge first: Two-Hand Tracking, Mental Counters, and Assembling Objects. Each of these tests represents a different ability factor. How sensitive are the results to the choice of the particular test representing a factor? Table 33 shows the validities of several alternative test combinations. To three decimal places, the validity is the same whether One-Hand or Two-Hand Tracking is chosen to represent Psychomotor Ability. Using Integrating Details instead of Assembling Objects, or Sequential Memory instead of Mental Counters decreases validity for Internal Criteria by only .001 and leaves School Grade prediction unchanged. The decrease is twice as large if Figural Reasoning is used instead of Mental Counters, but is still quite small. It seems that the important thing is to include good measures of the three ECAT factors. The particular test chosen may be largely a matter of chance.

Table 33

Means of Fully Corrected Multiple Correlations for Alternative Combinations of Three ECAT Tests Assuming 10 ASVAB Tests in Model

Predictors	School Grade Criteria $\overline{R}$	Internal Criteria $\overline{R}$
10 ASVAB Tests	.714	.620
+ Two-Hand Tracking + Mental Counters + Assembling Objects	.725	.645
+ One-Hand Tracking + Mental Counters + Assembling Objects	.725	.645
+ Two-Hand Tracking + Mental Counters + Integrating Details	.725	.644
+ Two-Hand Tracking + Sequential Memory + Assembling Objects	.725	.644
+ Two-Hand Tracking + Figural Reasoning + Assembling Objects	.725	.643

Note. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.

Turning to considerations of practicability, the ECAT tests can be classified according to ease of implementation. The three (formerly) P&P tests, Assembling Objects, Figural Reasoning, and Spatial Orientation, are easiest to implement. The three computerized cognitive tests, Mental Counters, Sequential memory, and Integrating Details, require availability of computers for administration. The psychomotor tests require not only a computer, but also a special Response Pedestal, making them the most expensive to implement and maintain.

How much of the incremental validity of ECAT is due to the psychomotor tests? Table 34 shows the results of a stepwise analysis with the psychomotor tests excluded. The last line of the table should be compared with the last line of Table 30. Without psychomotor tests, ECAT increases validity only .012 instead of .016 for School grades and only .019 instead of .033 for Internal Criteria. Thus 25% to 42% of ECAT's incremental validity comes from the psychomotor tests (principally Two-Hand Tracking), even if they are entered last into regression.

Table 34

Means of Fully Corrected Multiple Correlations for Stepwise Accretion Meta-analysis Without Psychomotor Tests in Model

Number of Predictors	School Grade Criteria: Predictor	$\overline{R}$	Internal Criteria: Predictor	$\overline{R}$
10	10 ASVAB Tests	.714	10 ASVAB Tests	.620
11	+ Mental Counters	.719	+ Mental Counters	.629
12	+ Assembling Objects	.722	+ Assembling Objects	.634
13	+ Figural Reasoning	.723	+ Figural Reasoning	.637
14	+ Sequential Memory	.724	+ Sequential Memory	.638
15	+ Spatial Orientation	.725	+ Spatial Orientation	.640
16	+ Integrating Details	.726	+ Integrating Details	.639

Suppose the Spatial Orientation test and all tests which require computer administration were omitted from the battery, leaving only Assembling Objects and Figural Reasoning. Table 35 shows that validity increases .009 for predicting Grades and .014 for predicting Internal Criteria, over the ASVAB alone. Thus these P&P tests can account for 56% and 42% of the ECAT incremental validity for predicting Grades or the Internal Criteria, respectively, if they are entered first into regression.

Table 35

Means of Fully Corrected Multiple Correlations for Stepwise Deletion Meta-analysis Without Computerized Tests in Model

Number of	School Grade Criteria		Internal Criteria	
Predictors	Predictor	$\overline{R}$	Predictor	$\overline{R}$
10	10 ASVAB Tests	.714	10 ASVAB Tests	.620
11	+ Assembling Objects	.719	+ Assembling Objects	.628
12	+ Spatial Orientation	.721	+ Figural Reasoning	.632
13	+ Figural Reasoning	.723	+ Spatial Orientation	.634

These relationships are depicted in Figure 12. It is clear that, once the P&P tests are forced into regression first, the other computerized cognitive tests produce very little further improvement. However, even after all cognitive tests are forced into regression, the psychomotor tests have substantial predictive power. Nevertheless, about half of the criterion variance is still unaccounted for.

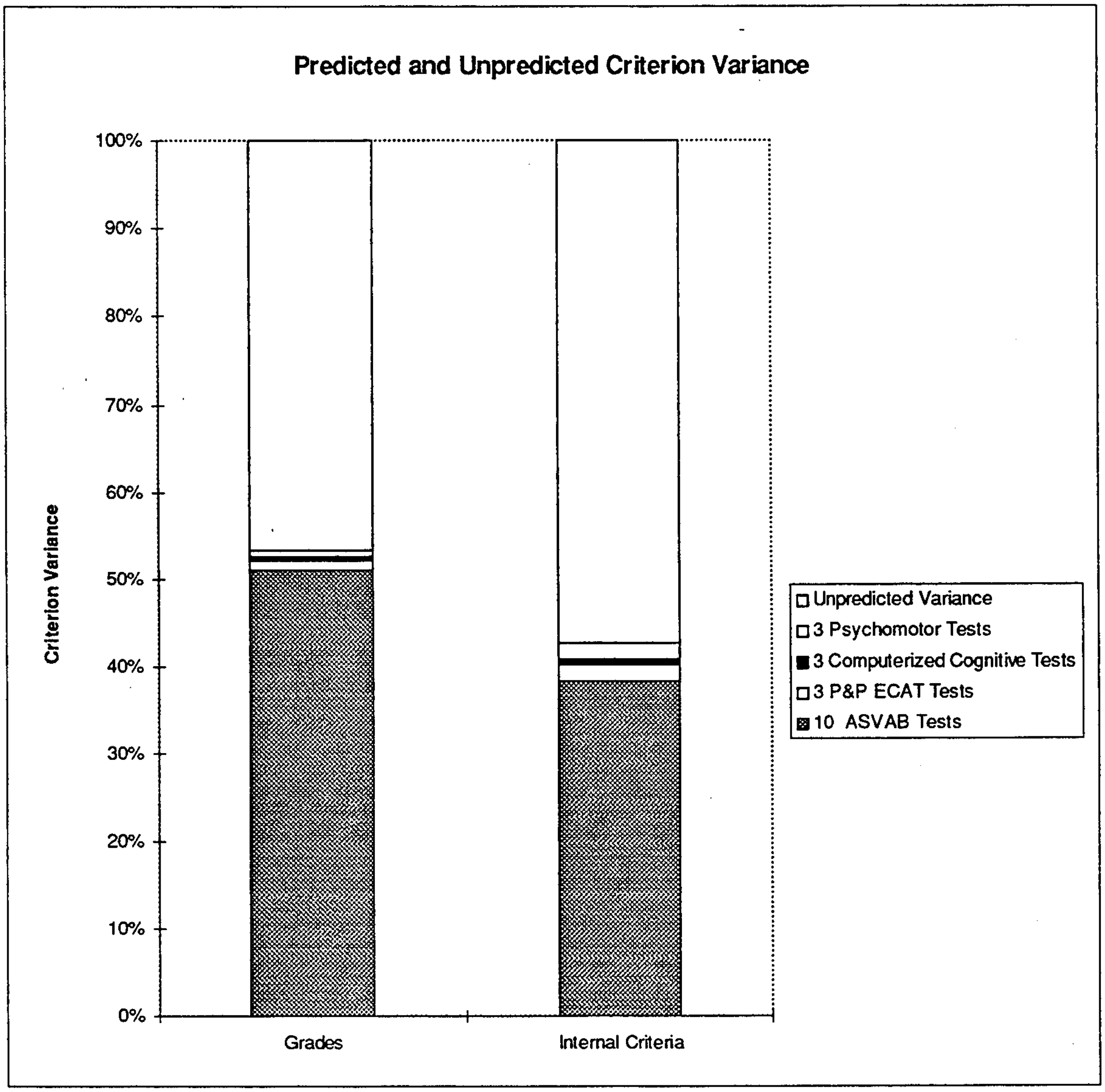


Figure 12. Prediction variance from paper-and-pencil, computerized cognitive, and psychomotor tests.

Discussion

It appears that chance plays a large role in the order of accretion or deletion. For example, Integrating Details was the first ECAT test deleted in all of the analyses, while Assembling Objects remained until only three ECAT tests were left. Yet, as the previous section has shown, there is no significant difference in the incremental validities for these two tests. The *nonsignificant*ly lower incremental validity for Integrating Details caused it to be removed first. Since the two tests measure similar constructs, and since spatial ability is essential, removing one of the tests causes the other one to assume an important position. Several other caveats are in order:

1. The battery that maximizes mean validity may not maximize differential prediction, which is important when the tests are used for classification.

2. Some tests require much less time or equipment to administer than others. Optimal battery construction should take these costs into account.

3. The mean validities are the averages over a set of schools that are not a representative, random sample of all military training schools.

4. Minor changes in the set of schools or criteria can cause large changes in the order with which predictors enter or leave the equations.

5. It may not be a good idea to select tests based on averages that include schools where the incremental validities are so small that the test will never be used there. Instead, tests may be selected for their maximum incremental validities, or the frequency with which their validities exceed a certain threshold for inclusion in selection equations.

6. It is unlikely that least-squares multiple regression weights will be used for selection or classification. Current practice is to use unit or low integer weights.

Validities of Unit-weighted Composites

Introduction

All of the results up to now have relied on least-squares linear multiple regression. In the ASVAB's operational use, integer-weighted composites of tests are used for selection and classification for two very good reasons:

1. On small samples, regression equations do not cross-validate as well as integer-weighted composites.

2. Full least-squares regression equations often involve negative weights, which, in effect, penalize examinees for doing well on those tests with negative weights.

Additionally, the regression analysis of incremental validity has been criticized as being too conservative. By optimally weighting all 10 ASVAB tests as a basis for comparison, it is argued, the ASVAB's validity has been inflated to unrealistic levels,[6] leaving little room for new tests to improve the validity.

The recommended alternative would be to estimate the incremental validity of new tests over the existing selector composite.

It is therefore desirable to examine the use of ECAT tests under conditions similar to the way the ASVAB is used now.

Method

Programs were developed to compute the validity of any given unit-weighted composite, and then search for the best test to add (with unit weights) to a composite to maximize validity. All correlations were corrected for range-restriction, but not for criterion unreliability. The programs were first applied to the existing selector composites to find which ECAT test would increase validity the most for a given school and find which additional ASVAB test would increase the validity the most. The purpose was to determine whether adding an ECAT test to a selector composite would increase validity more than adding an ASVAB test. In addition, since Assembling Objects appeared to be a particularly promising test, it was evaluated for possible addition to each operational selector composite.

For comparison, optimal regression equations were computed for each set of variables that had appeared in the unit-weighted composites.

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[6]However, the Wherry correction should shrink these estimates to their population values. Part of our purpose is to show that these criticisms are not valid, and that, on the contrary, the existing selector composites greatly *underestimate* the ASVAB's validity, resulting in incorrect estimates of incremental validity.

Results

The range-corrected validities of the additions to the operational selector composites are shown in Table 36 for Final School Grades and in Table 37 for Internal School Criteria. The three right-most columns give the validities of the integer-weighted composites and their differences. The first column of the three, labeled "Comp" gives the validity of the composite defined at the far left of the page. The second column, "Comp - OP," gives the difference between the first column and the validity of the operational composite. The third column, "Comp - (OP+ASVAB)," gives the difference between the first column and the validity of the operational composite plus the best ASVAB test to add to it. This column is the best comparison of ECAT with ASVAB.

With the exceptions of AC, EM, and EN Final School Grades, an ECAT test can be added to the operational composite to improve validity. However, in about half the cases, an ASVAB test will improve validity even more than an ECAT test. Significant cases where an ECAT test has much greater incremental validity than any ASVAB test are the 11H criteria using Two-Hand Tracking, APS Typing Speed using Sequential memory, and ATC Basic Ground Approach Control using Mental Counters,

Assembling Objects is seldom better than an ASVAB test for improving an operational selector composite if added with unit weight except for the 11H and ATC criteria, which are inconsistent between the alternate curricula for those schools..

The columns on the left give the results of the regression analyses with the same variables. In many cases, the integer weights have validities about the same as the regression's multiple correlation. However, the differences are large for 11H, APS, AV, EN, and EM Grades, and 11H(B), AV, AO, ATC, AC, and ET Internal Criteria. In many of these schools, the optimal weights for one or more ASVAB tests were close to zero or negative, suggesting that the operational selector composite could be improved by deleting a test.

The relative incremental validities for ECAT and ASVAB tests that were observed for integer weighted composites are confirmed in regression-weighted equations in all but six instances, that is., the (Op+ECAT) - (Op+ASVAB) validities have the same sign as the Multiple correlation differences except in GM and AE grades and ET, FC, OS, and AE performance, where the differences are close to zero. Thus, in most cases, the results are not due to the weighting method, but to the exclusion of some important ASVAB predictors from the operational selector composites. This exclusion permits the selector composite to be improved more by adding an ASVAB test than by adding an ECAT test.

Table 36

Beta Weights, Multiple Rs, and Validities for Composites of Tests (Operational Composite, Adding One ASVAB, One ECAT, or Assembling Objects) for School Grade Criteria

School/Criterion/ Composite	Standardized Regression Weights					Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
						Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
11H(A)5 (EVTSUM)	AR	CS	MC	AS	Added Test						
OP	.044	.019	.196			.347			.327		
Op+ASVAB	-.012	-.005	.166	.143	.148(VE)	.361	.014		.340	.013	
OP+ECAT	.033	-.001	.141	.147	.177(T2)	.379	.032	.018	.359	.032	.019
OP+AO	-.005	-.000	.125	.148	.207(AO)	.382	.035	.021	.357	.030	.017
11H(B)5 (EVTSUM)	AR	CS	MC	AS	Added Test						
OP	.072	.099	.233	.061		.346			.353		
Op+ASVAB	.007	-.010	.237	.081	.206(NO)	.374	.028		.369	.016	
OP+ECAT	.054	.066	.141	.033	.293(T2)	.431	.085	.057	.410	.057	.041
OP+AO	.050	.090	.201	.054	.091(AO)	.349	.004	-.024	.362	.009	-.006
13F1 (FSG)	AR	CS	MC	MK	Added Test						
OP	.261	.189	.271	.151		.682			.680		
Op+ASVAB	.225	.200	.165	.191	.172(AS)	.694	.012		.696	.015	
OP+ECAT	.220	.185	.207	.117	.186(ID)	.696	.014	.002	.697	.016	.001
OP+AO	.234	.178	.206	.126	.173(AO)	.695	.013	.001	.696	.016	.000
APS1 (FSG)	VE	NO	CS		Added Test						
OP	.579	.154	.071			.686			.608		
Op+ASVAB	.347	.041	.052		.449(AR)	.761	.075		.693	.086	
OP+ECAT	.443	.118	.053		.321(FR)	.739	.053	-.022	.685	.077	-.008
OP+AO	.501	.147	.047		.216(AO)	.712	.026	-.049	.658	.050	-.035
AO1 (FSG)	AR	MK	EI	GS	Added Test						
OP	.146	.361	.185	.130		.670			.666		
Op+ASVAB	.108	.321	.195	.131	.155(CS)	.683	.013		.684	.018	
OP+ECAT	.135	.358	.179	.104	.119(TI)	.678	.008	-.005	.671	.005	-.013
OP+AO	.121	.344	.167	.115	.107(AO)	.674	.004	-.009	.670	.004	-.014

Table 36 (continued)

School/Criterion/ Composite	Standardized Regression Weights					Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
						Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
AV1 (FSG)	AR	MK	EI	GS	Added Test						
OP	.296	.363	.261	.038		.791			.776		
Op+ASVAB	.281	.347	.265	.038	.063(CS)	.792	.002		.773	-.003	
OP+ECAT	.236	.326	.263	.037	.155(CT)	.800	.010	.008	.792	.015	.018
OP+AO	.272	.346	.244	.024	.104(AO)	.795	.004	.003	.778	.002	.005
ET2 (FSG2)	AR	MK	EI	GS	Added Test						
OP	.432	.187	.156	.175		.790			.789		
Op+ASVAB	.383	.135	.170	.176	.200(CS)	.808	.018		.814	.025	
OP+ECAT	.351	.140	.168	.166	.216(SM)	.808	.018	.000	.815	.026	.002
OP+AO	.389	.156	.126	.150	.183(AO)	.802	.012	-.006	.804	.015	-.010
FC1 (FSG)	AR	MK	EI	GS	Added Test						
OP	.316	.230	.275	.155		.798			.796		
Op+ASVAB	.282	.224	.234	.125	.124(MC)	.802	.004		.799	.003	
OP+ECAT	.272	.201	.267	.135	.136(FR)	.805	.007	.003	.802	.006	.003
OP+AO	.287	.209	.254	.137	.125(AO)	.804	.006	.002	.801	.004	.002
GM1 (FSG)	AR	MK	EI	GS	Added Test						
OP	.344	.182	.192	.119		.693			.689		
Op+ASVAB	.297	.174	.175	.024	.192(VE)	.703	.010		.697	.008	
OP+ECAT	.297	.153	.194	.119	.120(CT)	.699	.006	-.004	.698	.009	.001
OP+AO	.330	.172	.182	.111	.063(AO)	.694	.001	-.009	.686	-.003	-.011
MM1 (FSG)	AR	MK	EI	GS	Added Test						
OP	.126	.144	.186	.162		.500			.502		
Op+ASVAB	.094	.186	.095	.127	.167(AS)	.513	.013		.515	.013	
OP+ECAT	.090	.118	.160	.140	.154(AO)	.514	.015	.002	.517	.015	.002
OP+AO	.090	.118	.160	.140	.154(AO)	.514	.015	.002	.517	.015	.002

Table 36 (continued)

School/Criterion/ Composite	Standardized Regression Weights				Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
					Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
OS1 (FSG)	VE	MK	CS	Added Test						
OP	.277	.431	.208		.738			.729		
Op+ASVAB	.191	.303	.191	.255(AR)	.755	.017		.754	.024	
OP+ECAT	.258	.355	.180	.187(CT)	.754	.016	-.001	.749	.019	-.005
OP+AO	.241	.379	.200	.158(AO)	.750	.012	-.005	.743	.013	-.011
RM1 (FSG)	VE	MK	CS	Added Test						
OP	.399	.270	.193		.690			.685		
Op+ASVAB	.296	.116	.172	.307(AR)	.717	.026		.714	.029	
OP+ECAT	.353	.195	.190	.194(ID)	.708	.017	-.009	.706	.021	-.008
OP+AO	.372	.231	.187	.119(AO)	.696	.006	-.020	.688	.003	-.026
EN1 (FSG)	MK	AS		Added Test						
OP	.446	.440			.684			.685		
Op+ASVAB	.337	.360		.236(VE)	.708	.024		.706	.022	
OP+ECAT	.376	.396		.150(ID)	.694	.010	-.014	.683	-.002	-.024
OP+AO	.401	.405		.111(AO)	.689	.006	-.018	.671	-.014	-.036
ATC1 (FSG)	VE	AR		Added Test						
OP	.245	.391			.575			.574		
Op+ASVAB	.187	.304		.203(MC)	.594	.019		.595	.021	
OP+ECAT	.239	.283		.201(CT)	.598	.023	.004	.600	.026	.005
OP+AO	.218	.317		.178(AO)	.594	.018	-.001	.593	.019	-.002
AC1 (FSG)	AR	MK	GS	Added Test						
OP*	.270	.458	.218		.821			.829		
Op+ASVAB	.225	.406	.226	.196(CS)	.837	.017		.847	.019	
OP+ECAT	.233	.436	.198	.108(FR)	.822	.002	-.015	.830	.001	-.017
OP+AO	.247	.445	.198	.086(AO)	.821	.000	-.017	.826	-.003	-.021

* The integer-weighted composite is AR + 2MK + GS.

Table 36 (continued)

School/Criterion/ Composite	Standardized Regression Weights				Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
					Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
AE1 (FSG)	AR	MK	GS	Added Test						
OP*	.292	.091	.317		.608			.583		
Op+ASVAB	.225	.155	.208	.219(AS)	.632	.025		.624	.041	
OP+ECAT	.217	.048	.266	.239(ID)	.635	.027	.002	.613	.030	-.011
OP+AO	.242	.062	.275	.185(AO)	.625	.017	-.007	.607	.024	-.017
EM1 (FSG)	AR	MK	GS	Added Test						
OP*	.320	.240	.184		.650			.643		
Op+ASVAB	.283	.254	.091	.173(EI)	.663	.013		.659	.016	
OP+ECAT	.289	.222	.164	.099(ID)	.654	.004	-.009	.649	.006	-.010
OP+AO	.311	.235	.177	.034(AO)	.650	.000	-.013	.638	-.005	-.021
AMS1 (FSG)	AR	MC	AS	Added Test						
OP	.379	.312	.214		.757			.755		
Op+ASVAB	.283	.301	.246	.228(CS)	.785	.027		.788	.032	
OP+ECAT	.326	.293	.228	.111(SM)	.762	.005	-.023	.757	.002	-.030
OP+AO	.349	.275	.207	.107(AO)	.761	.004	-.024	.755	-.000	-.032

Notes 1ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade
2For definitions of ASVAB and ECAT tests, see Tables 1–2; for definitions of schools and criteria, see Tables 12–14.

* The integer-weighted composite is AR + 2MK + GS.

Table 37

Beta Weights, Multiple Rs, and Validities for Composites of Tests (Operational Composite, Adding One ASVAB, One ECAT, or Assembling Objects for Internal School Criteria

School/Criterion/ Composite	Standardized Regression Weights					Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
						Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
11H(A)6 (TO_1)	AR	CS	MC	AS	Added Test						
OP	-.003	.123	.134	.040		.203			.208		
Op+ASVAB	-.041	.060	.136	.052	.120(NO)	.216	.014		.222	.015	
OP+ECAT	-.014	.103	.080	.023	.173(T2)	.251	.048	.034	.241	.033	.018
OP+AO	-.006	.122	.130	.039	.010(AO)	.198	-.004	-.018	.204	-.004	-.018
11H(B)9 (ITVTOW)	AR	CS	MC	AS	Added Test						
OP	-.134	-.062	.165	.016		.114			.003		
Op+ASVAB	-.156	-.064	.145	.003	.066(GS)	.109	-.004		.016	.012	
OP+ECAT	-.150	-.091	.083	-.010	.260(T2)	.252	.138	.143	.067	.063	.051
OP+AO	-.172	-.077	.110	.003	.160(AO)	.162	.048	.053	.034	.031	.018
13F3 (FIRING)	AR	CS	MC	MK	Added Test						
OP	.250	.166	.176	.132		.568			.569		
Op+ASVAB	.196	.144	.130	.115	.164(VE)	.580	.012		.582	.013	
OP+ECAT	.220	.153	.167	.113	.102(SM)	.573	.005	-.006	.574	.005	-.008
OP+AO	.237	.161	.143	.119	.087(AO)	.571	.003	-.008	.570	.002	-.012
APS3 (AFPT70)	VE	NO	CS		Added Test						
OP	.187	.118	.157			.358			.365		
Op+ASVAB	.111	.081	.150		.147(AR)	.372	.013		.381	.016	
OP+ECAT	.125	.086	.126		.216(SM)	.405	.046	.033	.406	.042	.025
OP+AO	.147	.114	.144		.109(AO)	.369	.011	-.003	.379	.014	-.002
AO2 (PRACTL)	AR	MK	EI	GS	Added Test						
OP	.036	.314	.117	-.010		.375			.364		
Op+ASVAB	-.023	.252	.133	-.009	.239(CS)	.429	.054		.410	.046	
OP+ECAT	-.021	.277	.106	-.036	.177(FR)	.395	.020	-.034	.385	.021	-.025
OP+AO	.007	.294	.096	-.027	.125(AO)	.384	.009	-.045	.378	.014	-.033

Table 37 (continued)

School/Criterion/ Composite	Standardized Regression Weights					Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
						Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
AV4 (PERFORM)	AR	MK	EI	GS	Added Test						
OP	.166	.209	.369	-.135		.513			.476		
Op+ASVAB	.093	.197	.281	-.198	.266(MC)	.541	.028		.500	.024	
OP+ECAT	.125	.180	.340	-.159	.179(AO)	.532	.019	-.010	.497	.021	-.004
OP+AO	.125	.180	.340	-.159	.179(AO)	.532	.019	-.010	.497	.021	-.004
ET3 (PERF)	AR	MK	EI	GS	Added Test						
OP	.503	.262	.137	-.142		.679			.624		
Op+ASVAB	.454	.210	.150	-.141	.198(CS)	.698	.019		.663	.039	
OP+ECAT	.469	.251	.104	-.170	.216(T2)	.704	.025	.006	.651	.028	-.011
OP+AO	.494	.255	.131	-.148	.039(AO)	.675	-.004	-.024	.620	-.004	-.043
FC2 (RADAR)	AR	MK	EI	GS	Added Test						
OP	.239	.054	.264	.187		.616			.608		
Op+ASVAB	.210	.093	.179	.155	.156(AS)	.625	.009		.627	.018	
OP+ECAT	.221	.049	.245	.172	.122(T2)	.626	.009	.000	.619	.011	-.008
OP+AO	.217	.038	.248	.174	.095(AO)	.620	.004	-.005	.611	.003	-.016
GM3 (HALF2)	AR	MK	EI	GS	Added Test						
OP	.302	.101	.182	.216		.662			.662		
Op+ASVAB	.248	.173	.028	.158	.285(AS)	.692	.030		.687	.025	
OP+ECAT	.277	.084	.165	.202	.104(AO)	.667	.004	-.025	.666	.004	-.021
OP+AO	.277	.084	.165	.202	.104(AO)	.667	.004	-.025	.666	.004	-.021
OS3 (PERF)	VE	MK	CS		Added Test						
OP	.175	.415	.207			.646			.635		
Op+ASVAB	.058	.335	.222		.275(MC)	.682	.035		.669	.034	
OP+ECAT	.150	.313	.170		.255(CT)	.680	.034	-.001	.675	.040	.006
OP+AO	.122	.335	.195		.241(AO)	.678	.032	-.003	.672	.037	.002

Table 37 (continued)

School/Criterion/ Composite	Standardized Regression Weights				Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
					Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
RM2 (PHASE3)	VE	MK	CS	Added Test						
OP	.331	.226	.092		.528			.518		
Op+ASVAB	.230	.157	.105	.236(MC)	.558	.030		.559	.041	
OP+ECAT	.288	.155	.089	.181(ID)	.547	.019	-.011	.545	.027	-.014
OP+AO	.296	.174	.084	.155(AO)	.543	.014	-.016	.539	.021	-.020
ATC(A)4 (BLK5A)	VE	AR		Added Test						
OP	.025	.414			.421			.396		
Op+ASVAB	-.022	.344		.163(MC)	.434	.013		.418	.023	
OP+ECAT	.015	.237		.328(CT)	.498	.077	.064	.478	.082	.059
OP+AO	.003	.354		.144(AO)	.434	.013	-.000	.421	.025	.003
ATC(B)4 (BLK5A)	VE	AR		Added Test						
OP	-.041	.420			.389			.342		
Op+ASVAB	-.071	.286		.217(MK)	.414	.025		.385	.043	
OP+ECAT	-.050	.252		.313(CT)	.465	.076	.051	.426	.084	.040
OP+AO	-.076	.322		.233(AO)	.433	.045	.019	.398	.056	.013
AC2 (PERF)	AR	MK	GS	Added Test						
OP*	.135	.275	-.001		.332			.372		
Op+ASVAB	.073	.204	.010	.267(CS)	.398	.066		.419	.047	
OP+ECAT	-.000	.192	-.006	.371(SM)	.446	.113	.047	.428	.056	.010
OP+AO	.058	.231	-.065	.286(AO)	.396	.064	-.003	.410	.038	-.009
AE2 (SUM2)	AR	MK	GS	Added Test						
OP*	.284	.035	.314		.555			.522		
Op+ASVAB	.246	.072	.252	.125(AS)	.562	.007		.551	.029	
OP+ECAT	.270	.031	.282	.134(TI)	.567	.012	.005	.543	.022	-.007
OP+AO	.245	.013	.282	.143(AO)	.565	.010	.003	.540	.019	-.010

* The integer-weighted composite is AR + 2MK + GS

Table 37 (continued)

School/Criterion/ Composite	Standardized Regression Weights				Regression Weight Analyses Multiple Rs & Differences			Integer Weight Analyses Validities & Differences		
					Comp	Comp – Op	Comp – (Op+ASVAB)	Comp	Comp – Op	Comp – (Op+ASVAB)
EM2 (PHASE1)	AR	MK	GS	Added Test						
OP*	.331	.286	.148		.672			.667		
Op+ASVAB	.292	.300	.051	.181(EI)	.686	.014		.680	.013	
OP+ECAT	.297	.265	.130	.101(FR)	.676	.004	-.010	.672	.005	-.008
OP+AO	.315	.276	.135	.061(AO)	.674	.001	-.012	.665	-.002	-.015
AMS2 (PERF)	AR	MC	AS	Added Test						
OP	.261	.217	.176		.539			.545		
Op+ASVAB	.160	.205	.210	.239(CS)	.579	.040		.587	.042	
OP+ECAT	.203	.145	.163	.207(AO)	.562	.023	-.018	.570	.025	-.017
OP+AO	.203	.145	.163	.207(AO)	.562	.023	-.018	.570	.025	-.017

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.
2. For definitions of ASVAB and ECAT tests, see Tables 1–2; for definitions of schools and criteria, see Tables 12–14.
* The integer-weighted composite is AR + 2MK + GS.

Discussion

Although these conclusions must remain tentative, until confirmed by cross-validation in new samples, it appears that the operational composites could be substantially improved by adding more ASVAB tests to most of them. The use of integer weights degrades validity where exact weights are negative, as they often are with the Internal Criteria, and in these cases the operational composite could be improved by removing a test. In many cases potential validity improvements from revising the operational composites exceed those from enhancing the ASVAB with the ECAT tests, although both improvements would be desirable.

So far, we have ignored the benefits that might be derived from improved differential validity and classification efficiency that a larger and more diverse battery could produce. However, the exact weights derived from these analyses could be evaluated to determine ASVAB tests that could be replaced by ECAT tests. Eliminating one of two ASVAB tests with the same underlying dimension for even a few selector composites should improve classification efficiency by lowering the intercorrelations of the operational selector composites. For that matter, leaving all operational composites intact and adding an ECAT test to composites of an occupational group (where incremental validity has been shown) would improve classification efficiency.

Given the vagaries of the operational selector composites, the best index of the predictive potential of ECAT tests remains the incremental validity determined from full-model regression equations in the earlier sections of this report. At the same time, the ultimate utility of ECAT can only be assessed in the context of the way the tests will be used operationally for selection and classification decisions.

General Discussion

We have analyzed the incremental validities of ECAT from four different perspectives: general ability, ability factors in multiple regression, tests and composites in multiple regression, and unit-weighted selector composites. The results of the different approaches are consistent with one another, with the exception of the unit-weighted selector composites, where the problem was inadequate ASVAB weighting. The incremental validity of ECAT is not the result of tricky regression weighting, however, because it shows up even in the simple validity of "***g***".

What are we to make of the fact that the ECAT validity increments depend so strongly on which criteria are used to measure school performance? If the ECAT project were to be evaluated solely on the basis of its ability to improve prediction of Final School Grades, or even school attrition, it would have to be considered a failure. The highest significant validity gain for predicting FSG was .024, with many schools showing no gain at all. This result was expected: we had no reason to think that psychomotor ability, for example, would be related to performance on the kinds of written tests that form the basis for most Final School Grades. The ASVAB probably is optimized already for predicting academic achievement. It contains tests of electronics, science, verbal, and mathematical knowledge that was acquired in school. Our results show that its corrected validity averages better than .78 for predicting FSG, an extremely high value for most aptitude batteries. It is, perhaps, surprising that the ECAT battery could boost the mean validity as high as it did, to .80.

On the other hand, the incremental validity of ECAT for predicting hands-on performance averaged better than .03 and exceeded .10 for some schools. Potentially, these validity increases could mean better hands-on job performance if recruits were classified on the basis of the relevant ECAT tests. Unfortunately, hands-on performance is seldom measured or publicly available, which is why we labeled these "internal" criteria. Because hands-on performance is nearly invisible to external decision makers without special studies, validity improvements are likely to go unnoticed. Worse, these criteria are ephemeral; they change or completely disappear when the curriculum changes, as it frequently does. It may be impossible to cross-validate a regression equation on the same school a year later because the criterion no longer exists! Nevertheless, the same ability that was needed to perform one laboratory exercise may show up on a different one, or on subsequent job performance.

Are any of the results reproducible? Yes, the ECAT results for the Army's 11H Heavy Antiarmor Weapons school are actually cross-validations of earlier studies at the same school by Smith and Walker (1988) who confirmed a study by Grafton, Czarnolewski, and Smith (1989) showing the validity of tracking and spatial tests for predicting 11H TOW simulator performance. In addition, the ECAT study found that psychomotor and spatial tests improved prediction of EVTSUM criteria in two different samples from the 11H school.

Another result that was replicated within the ECAT study itself was a very large validity improvement from Working Memory and Spatial tests for predicting Air Traffic Control operations. The same result was found for two different samples from the Air Force ATC school and from the Navy's AC school. Because Air Traffic control is so critical to human lives and to the safety of equipment, anything that could improve the selection of Air Traffic Controllers would be very valuable to both military and civilian aviation.

The ultimate use of these findings depends on practical and economic considerations beyond the scope of this scientific study. It is not clear, for example, that testing every incoming military enlisted applicant with the ECAT tests is an efficient way to proceed. It may be possible to give ECAT tests to only those applicants who are likely to be assigned to 11H, Air Traffic Control, or certain other specialties. Although computerized testing will become nearly universal with the full-scale implementation of CAT-ASVAB, the response pedestals needed for the psychomotor tests will not be part of that system. Each response pedestal costs more than a computer. On the other hand, further research might develop a mouse-based tracking test that is equally effective in measuring psychomotor ability. In that case, routine psychomotor testing of all applicants might become feasible.

Conclusions

1. Many ECAT tests have substantial simple validities for predicting school performance.

2. In some military training courses, the ASVAB's prediction of school practical performance can be substantially improved by using ECAT tests in optimally- weighted composites.

3. All ECAT tests have statistically significant incremental validity over the ASVAB alone.

4. Validity increases are greatest (averaging 5.7%) when laboratory or simulator performance criteria are used, rather than school grades (averaging 1.7%).

5. Increases for some schools are much larger than this, while other schools have no significant validity improvement.

6. Very large cross-validated incremental validities were found for predicting Air Traffic Control operations, using Working memory and Spatial tests.

7. Very large cross-validated incremental validities were found for predicting 11H Heavy Antiarmor Weapons performance.

8. Factor scores are more than 98% as valid as individual tests in multiple regression, but relying on "g" alone reduces validity by as much as 8.9% on the average.

9. ECAT tests can be used to broaden the estimate of general mental ability, or "g" produced by the ASVAB. This enhanced "g" has validity increments for predicting practical performance criteria which are nearly as large as the validity increments from using all tests in multiple regression.

10. The Spatial ability dimension is essential for prediction. Either Assembling Objects or Integrating Details tests can be omitted from the battery, provided the other remains.

11. Both working memory tests, Mental Counters and Sequential Memory, are essential for maximal prediction and neither can be deleted from the ECAT battery without a significant decrease in validity.

12. The Psychomotor tests account for 25% of the mean validity gain in predicting school grades and 44% of the gain in predicting the Internal school criteria, even after all other predictors are entered.

13. Two P&P tests, Assembling Objects and Figural Reasoning, together can produce 44% and 35% of the ECAT mean validity gain for predicting Grades and Internal Criteria, respectively, if they are entered first into regression.

14. The Spatial Orientation test is redundant and can be eliminated from the ECAT battery without a significant decrease in validity, provided that the other ASVAB and ECAT tests remain.

15. About 75% of the incremental validity of ECAT can be attained by using just three tests, each one representing a different ECAT factor.

16. The best three ECAT tests for increasing validity are Two-Hand Tracking, Mental Counters, and Assembling Objects.

17. Existing selector composites can be improved by adding ASVAB tests to them. In most cases, the validity improvements from doing so exceed those from adding an ECAT test with unit weights.

18. The estimates of ECAT's incremental validity are very sensitive to the type and quality of criteria used to evaluate the tests. Continued improvement of the ASVAB's predictive validity requires improved quality in the criterion measures used for validation.

Recommendations

1. Consideration should be given toward the eventual incorporation into ASVAB of a Spatial Ability measure, such as Assembling Objects.

2. If CAT-ASVAB is universally implemented, then consideration should be given toward including computerized tests of working memory, such as Mental Counters.

3. The Mental Counters test should be considered for supplementary administration to potential students in the Air Force and Navy Air Traffic Control schools.

4. The Two-Hand Tracking test should be considered for supplementary administration to potential students in the Army Heavy Antiarmor Weapons school (11H). Its cost/benefits for wider operational testing should be evaluated under different concepts of operations.

5. A variety of alternative tracking tests should be investigated, to determine if a mouse, trackball, or other off-the-shelf equipment could serve as well as slide potentiometers and joysticks. Human factors work on alternative tracking item types and screen displays should be supported.

6. Development of alternate forms and/or adaptive item pools should be started for ECAT tests.

7. The most promising ECAT tests should be normed.

8. Research on optimal non-negative weighting of ASVAB tests for maximal cross-validated classification efficiency should be given high priority. Operational selector composites eventually should be replaced by these optimal weighting methods.

9. Military training schools should be encouraged to incorporate continuously-scored practical performance measures in their intermediate and final grades. The statistical properties of FSG, including reliability and validity, should be continuously monitored and updated, particularly following any shift in curricula.

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Appendix A

ASVAB Population Statistics

Table A-1

Means, Standard Deviations, and Correlations of ASVAB Tests for Fiscal Year 1991 Military Applicants (*N* = 650,278)

Variable	AFQT	GS	AR	WK	PC	NO
Mean	52.59779	50.61501	50.66362	51.31136	51.15582	52.51222
Std. Dev.	23.6111	8.772641	8.645407	7.354141	7.964013	8.013076
AFQT	1	0.746484	0.874185	0.829683	0.760957	0.479759
GS	0.746484	1	0.611079	0.720105	0.607873	0.275094
AR	0.874185	0.611079	1	0.596262	0.574273	0.470311
WK	0.829683	0.720105	0.596262	1	0.731601	0.324392
PC	0.760957	0.607873	0.574273	0.731601	1	0.395913
NO	0.479759	0.275094	0.470311	0.324392	0.395913	1
CS	0.434399	0.248734	0.39535	0.327805	0.385869	0.640106
AS	0.406062	0.520184	0.400411	0.43662	0.339055	0.046951
MK	0.829985	0.554223	0.706944	0.49678	0.499731	0.496123
MC	0.641152	0.637695	0.613441	0.547276	0.485226	0.227886
EI	0.547772	0.624531	0.486796	0.534385	0.444472	0.14525
VE	0.860154	0.727385	0.625712	0.972128	0.86498	0.368634

Variable	CS	AS	MK	MC	EI	VE
Mean	52.2662	51.40873	51.2103	51.94077	50.33257	51.33477
Std. Dev.	7.811829	9.167697	8.689045	9.127189	8.855934	7.306167
AFQT	0.434399	0.406062	0.829985	0.641152	0.547772	0.860154
GS	0.248734	0.520184	0.554223	0.637695	0.624531	0.727385
AR	0.39535	0.400411	0.706944	0.613441	0.486796	0.625712
WK	0.327805	0.43662	0.49678	0.547276	0.534385	0.972128
PC	0.385869	0.339055	0.499731	0.485226	0.444472	0.86498
NO	0.640106	0.046951	0.496123	0.227886	0.14525	0.368634
CS	1	0.058285	0.40777	0.221165	0.147078	0.368472
AS	0.058285	1	0.196576	0.61808	0.669217	0.429827
MK	0.40777	0.196576	1	0.493874	0.369617	0.527314
MC	0.221165	0.61808	0.493874	1	0.630407	0.560015
EI	0.147078	0.669217	0.369617	0.630407	1	0.536475
VE	0.368472	0.429827	0.527314	0.560015	0.536475	1

Appendix B

Means, Standard Deviations, and Correlations of ASVAB and ECAT Predictors

Table B - 1

Uncorrected Means, Standard Deviations, and Intercorrelations of Predictors and Other Measures
(N = 10,963)

VARIABLE	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	VE	AFQT	CT	SM	ID	AO
MEAN	53.2548	53.6095	53.0435	53.2287	54.2075	53.2479	53.6141	55.1249	54.9579	52.5929	53.2058	61.1787	0.7242	0.6878	0.7597	0.6288
STD	7.4186	6.9048	5.3537	5.7400	6.5828	6.9367	8.0510	6.8758	7.7035	7.9453	5.0966	17.9174	0.1754	0.1339	0.1266	0.1929
GS	1.0000	0.4251	0.6044	0.4254	0.0086	-0.0008	0.4218	0.3450	0.5197	0.5211	0.6025	0.6128	0.1975	0.1917	0.3595	0.3370
AR	0.4251	1.0000	0.3991	0.3415	0.2582	0.1841	0.2445	0.5346	0.4477	0.3161	0.4185	0.7968	0.4298	0.4020	0.4287	0.3700
WK	0.6044	0.3991	1.0000	0.5200	0.0399	0.0830	0.3192	0.2699	0.3961	0.4031	0.9087	0.7406	0.1616	0.1955	0.2711	0.2458
PC	0.4254	0.3415	0.5200	1.0000	0.1201	0.1617	0.1947	0.2457	0.2918	0.2789	0.7262	0.6100	0.1638	0.1852	0.2037	0.1848
NO	0.0086	0.2582	0.0399	0.1201	1.0000	0.5214	-0.1271	0.2982	-0.0240	-0.0617	0.0714	0.2446	0.2145	0.1825	0.0708	0.0588
CS	-0.0008	0.1841	0.0830	0.1617	0.5214	1.0000	-0.0925	0.1992	0.0058	-0.0369	0.1148	0.2051	0.2072	0.1986	0.0914	0.1170
AS	0.4218	0.2445	0.3192	0.1947	-0.1271	-0.0925	1.0000	0.0063	0.4917	0.5691	0.3045	0.2601	0.0782	0.0407	0.2526	0.2705
MK	0.3450	0.5346	0.2699	0.2457	0.2982	0.1992	0.0063	1.0000	0.3106	0.1969	0.2849	0.7240	0.3728	0.3437	0.3683	0.3198
MC	0.5197	0.4477	0.3961	0.2918	-0.0240	0.0058	0.4917	0.3106	1.0000	0.5142	0.3969	0.4986	0.2863	0.2453	0.4573	0.4422
EI	0.5211	0.3161	0.4031	0.2789	-0.0617	-0.0369	0.5691	0.1969	0.5142	1.0000	0.3996	0.4080	0.1228	0.0917	0.3009	0.3010
VE	0.6025	0.4185	0.9087	0.7262	0.0714	0.1148	0.3045	0.2849	0.3969	0.3996	1.0000	0.8014	0.1783	0.2105	0.2743	0.2494
AFQT	0.6128	0.7968	0.7406	0.6100	0.2446	0.2051	0.2601	0.7240	0.4986	0.4080	0.8014	1.0000	0.3937	0.3903	0.4446	0.3918
CT	0.1975	0.4298	0.1616	0.1638	0.2145	0.2072	0.0782	0.3728	0.2863	0.1228	0.1783	0.3937	1.0000	0.5591	0.4605	0.4884
SM	0.1917	0.4020	0.1955	0.1852	0.1825	0.1986	0.0407	0.3437	0.2453	0.0917	0.2105	0.3903	0.5591	1.0000	0.3947	0.3965
ID	0.3595	0.4287	0.2711	0.2037	0.0708	0.0914	0.2526	0.3683	0.4573	0.3009	0.2743	0.4446	0.4605	0.3947	1.0000	0.5709
AO	0.3370	0.3700	0.2458	0.1848	0.0588	0.1170	0.2705	0.3198	0.4422	0.3010	0.2494	0.3918	0.4884	0.3965	0.5709	1.0000
T1	-0.1859	-0.1808	-0.1318	-0.1049	-0.0893	-0.0978	-0.1736	-0.1469	-0.2793	-0.1732	-0.1359	-0.1948	-0.3113	-0.2441	-0.3082	-0.3106
T2	-0.2303	-0.2111	-0.1769	-0.1257	-0.0621	-0.1007	-0.2288	-0.1521	-0.3427	-0.2213	-0.1743	-0.2290	-0.3121	-0.2538	-0.3236	-0.3522
FR	0.3441	0.4494	0.3006	0.2444	0.1115	0.1099	0.1733	0.3894	0.3988	0.2482	0.3077	0.4772	0.4614	0.4450	0.4959	0.4848
SO	0.3464	0.3915	0.2844	0.2112	0.0362	0.0750	0.2743	0.3316	0.4448	0.2990	0.2889	0.4257	0.4094	0.3562	0.4792	0.4911
TI	-0.2303	-0.1573	-0.1548	-0.1095	-0.0712	-0.0985	-0.1512	-0.1190	-0.2392	-0.1486	-0.1540	-0.1859	-0.2261	-0.2111	-0.2582	-0.3040
MEMORY	0.2204	0.4710	0.2022	0.1977	0.2249	0.2298	0.0673	0.4058	0.3011	0.1215	0.2202	0.4440	0.8831	0.8828	0.4843	0.5012
SPATIAL	0.3929	0.4505	0.2915	0.2191	0.0731	0.1176	0.2952	0.3881	0.5075	0.3396	0.2954	0.4718	0.5354	0.4464	0.8854	0.8871
TRACKING	-0.2236	-0.2106	-0.1658	-0.1239	-0.0814	-0.1067	-0.2161	-0.1607	-0.3342	-0.2119	-0.1666	-0.2277	-0.3350	-0.2675	-0.3395	-0.3561
AORT	0.0196	0.0776	0.0311	0.0391	-0.0326	-0.0387	-0.0058	0.1175	0.0603	0.0413	0.0359	0.0925	0.1704	0.0579	0.1455	0.2759
IDCT	0.0081	0.0511	0.0146	0.0518	0.0176	-0.0028	-0.0419	0.1209	0.0338	0.0178	0.0318	0.0805	0.1269	0.0305	0.2475	0.0819
IDDT	-0.1185	-0.1002	-0.1026	-0.0726	-0.0666	-0.0889	-0.1180	-0.0446	-0.1142	-0.0940	-0.1038	-0.1093	-0.0392	-0.0978	-0.0611	-0.0668
SORT	-0.0270	0.0116	-0.0136	0.0077	-0.0330	-0.0484	-0.0643	0.0501	-0.0317	-0.0132	-0.0086	0.0192	0.0694	-0.0149	0.0564	0.0876
FRRT	0.0109	0.0647	0.0313	0.0492	-0.0463	-0.0498	-0.0441	0.1201	0.0344	0.0347	0.0388	0.0906	0.0351	-0.0683	0.1096	0.0575
AO-1	0.2741	0.3251	0.1984	0.1617	0.0431	0.0872	0.2083	0.3099	0.3709	0.2499	0.2063	0.3482	0.4514	0.3547	0.4957	0.8368
AO-2	0.3084	0.3178	0.2245	0.1595	0.0573	0.1156	0.2578	0.2511	0.3956	0.2712	0.2244	0.3334	0.3980	0.3355	0.4975	0.8949

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table B-1 (continued)

VARIABLE	T1	T2	FR	SO	TI	MEMORY	SPATIAL	TRACKING	AORT	IDCT	IDDT	SORT	FRRT	AO-1	AO-2
MEAN	2765.37	3639.16	0.6689	0.5166	1.8350	0.0053	0.0134	-0.0008	18.6950	12.5066	2.8663	13.9647	18.7153	0.6344	0.5807
STD	391.7238	471.9778	0.1877	0.2473	0.6039	0.9956	1.0007	1.0032	5.5288	5.1293	0.7763	3.8645	4.6116	0.1995	0.2279
GS	-0.1859	-0.2303	0.3441	0.3464	-0.2303	0.2204	0.3929	-0.2236	0.0196	0.0081	-0.1185	-0.0270	0.0109	0.2741	0.3084
AR	-0.1808	-0.2111	0.4494	0.3915	-0.1573	0.4710	0.4505	-0.2106	0.0776	0.0511	-0.1002	0.0116	0.0647	0.3251	0.3178
WK	-0.1318	-0.1769	0.3006	0.2844	-0.1548	0.2022	0.2915	-0.1658	0.0311	0.0146	-0.1026	-0.0136	0.0313	0.1984	0.2245
PC	-0.1049	-0.1257	0.2444	0.2112	-0.1095	0.1977	0.2191	-0.1239	0.0391	0.0518	-0.0726	0.0077	0.0492	0.1617	0.1595
NO	-0.0893	-0.0621	0.1115	0.0362	-0.0712	0.2249	0.0731	-0.0814	-0.0326	0.0176	-0.0666	-0.0330	-0.0463	0.0431	0.0573
CS	-0.0978	-0.1007	0.1099	0.0750	-0.0985	0.2298	0.1176	-0.1067	-0.0387	-0.0028	-0.0889	-0.0484	-0.0498	0.0872	0.1156
AS	-0.1736	-0.2288	0.1733	0.2743	-0.1512	0.0673	0.2952	-0.2161	-0.0058	-0.0419	-0.1180	-0.0643	-0.0441	0.2083	0.2578
MK	-0.1469	-0.1521	0.3894	0.3316	-0.1190	0.4058	0.3881	-0.1607	0.1175	0.1209	-0.0446	0.0501	0.1201	0.3099	0.2511
MC	-0.2793	-0.3427	0.3988	0.4448	-0.2392	0.3011	0.5075	-0.3342	0.0603	0.0338	-0.1142	-0.0317	0.0344	0.3709	0.3956
EI	-0.1732	-0.2213	0.2482	0.2990	-0.1486	0.1215	0.3396	-0.2119	0.0413	0.0178	-0.0940	-0.0132	0.0347	0.2499	0.2712
VE	-0.1359	-0.1743	0.3077	0.2889	-0.1540	0.2202	0.2954	-0.1666	0.0359	0.0318	-0.1038	-0.0086	0.0388	0.2063	0.2244
AFQT	-0.1948	-0.2290	0.4772	0.4257	-0.1859	0.4440	0.4718	-0.2277	0.0925	0.0805	-0.1093	0.0192	0.0906	0.3482	0.3334
CT	-0.3113	-0.3121	0.4614	0.4094	-0.2261	0.8831	0.5354	-0.3350	0.1704	0.1269	-0.0392	0.0694	0.0351	0.4514	0.3980
SM	-0.2441	-0.2538	0.4450	0.3562	-0.2111	0.8828	0.4464	-0.2675	0.0579	0.0305	-0.0978	-0.0149	-0.0683	0.3547	0.3355
ID	-0.3082	-0.3236	0.4959	0.4792	-0.2582	0.4843	0.8854	-0.3395	0.1455	0.2475	-0.0611	0.0564	0.1096	0.4957	0.4975
AO	-0.3106	-0.3522	0.4848	0.4911	-0.3040	0.5012	0.8871	-0.3561	0.2759	0.0819	-0.0668	0.0876	0.0575	0.8368	0.8949
T1	1.0000	0.7317	-0.2672	-0.2940	0.3205	-0.3146	-0.3491	0.9308	-0.0939	-0.0901	0.0338	-0.0251	-0.0475	-0.2740	-0.2654
T2	0.7317	1.0000	-0.2818	-0.3280	0.3381	-0.3205	-0.3813	0.9302	-0.0983	-0.0332	0.0803	-0.0080	-0.0222	-0.3056	-0.3052
FR	-0.2672	-0.2818	1.0000	0.4379	-0.2156	0.5133	0.5532	-0.2950	0.1554	0.1471	-0.0563	0.0548	0.1264	0.4396	0.4054
SO	-0.2940	-0.3280	0.4379	1.0000	-0.2062	0.4336	0.5474	-0.3342	0.1435	0.1085	-0.0792	0.0549	0.0599	0.4375	0.4178
TI	0.3205	0.3381	-0.2156	-0.2062	1.0000	-0.2476	-0.3173	0.3539	0.0980	0.0862	0.1276	0.1109	0.1476	-0.2124	-0.3086
MEMORY	-0.3146	-0.3205	0.5133	0.4336	-0.2476	1.0000	0.5560	-0.3412	0.1293	0.0892	-0.0776	0.0309	-0.0188	0.4565	0.4154
SPATIAL	-0.3491	-0.3813	0.5532	0.5474	-0.3173	0.5560	1.0000	-0.3925	0.2380	0.1855	-0.0722	0.0813	0.0941	0.7524	0.7863
TRACKING	0.9308	0.9302	-0.2950	-0.3342	0.3539	-0.3412	-0.3925	1.0000	-0.1033	-0.0663	0.0613	-0.0178	-0.0375	-0.3114	-0.3066
AORT	-0.0939	-0.0983	0.1554	0.1435	0.0980	0.1293	0.2380	-0.1033	1.0000	0.3099	0.2317	0.4802	0.4703	0.4344	0.0705
IDCT	-0.0901	-0.0332	0.1471	0.1085	0.0862	0.0892	0.1855	-0.0663	0.3099	1.0000	0.4644	0.3229	0.4584	0.1593	-0.0067
IDDT	0.0338	0.0803	-0.0563	-0.0792	0.1276	-0.0776	-0.0722	0.0613	0.2317	0.4644	1.0000	0.2951	0.3746	0.0030	-0.1128
SORT	-0.0251	-0.0080	0.0548	0.0549	0.1109	0.0309	0.0813	-0.0178	0.4802	0.3229	0.2951	1.0000	0.4323	0.1781	-0.0118
FRRT	-0.0475	-0.0222	0.1264	0.0599	0.1476	-0.0188	0.0941	-0.0375	0.4703	0.4584	0.3746	0.4323	1.0000	0.1638	-0.0463
AO-1	-0.2740	-0.3056	0.4396	0.4375	-0.2124	0.4565	0.7524	-0.3114	0.4344	0.1593	0.0030	0.1781	0.1638	1.0000	0.5109
AO-2	-0.2654	-0.3052	0.4054	0.4178	-0.3086	0.4154	0.7863	-0.3066	0.0705	-0.0067	-0.1128	-0.0118	-0.0463	0.5109	1.0000

Other ECAT Exploratory Measures

AORT = AO Arithmetic Mean Item Response Latency
SORT = SO Arithmetic Mean Item Response Latency
AO-2 = AO Proportion Correct of Final 17 Items (Jig-saw)
IDCT = ID Geometric Mean Component Latency
FRRT = FR Arithmetic Mean Item Response Latency
IDDT = ID Geometric Mean Decision Latency
AO-1 = AO Proportion Correct of First 15 Items (Semi-mechanical)

Table B - 2

Range-Corrected Means, Standard Deviations, and Intercorrelations of Predictors and Other Measures
(N = 10,963)

VARIABLE	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	VE	AFQT	CT	SM	ID	AO
MEAN	50.6150	50.6636	51.3114	51.1558	52.5122	52.2662	51.4087	51.2103	51.9408	50.3326	51.3518	51.0176	0.6772	0.6554	0.7209	0.5746
STD	8.7726	8.6454	7.3541	7.9640	8.0131	7.8118	9.1677	8.6890	9.1272	8.8559	7.2490	26.3284	0.1920	0.1456	0.1404	0.2112
GS	1.0000	0.6111	0.7201	0.6079	0.2751	0.2487	0.5202	0.5542	0.6377	0.6245	0.7213	0.7488	0.3684	0.3606	0.5024	0.4743
AR	0.6111	1.0000	0.5963	0.5743	0.4703	0.3953	0.4004	0.7069	0.6134	0.4868	0.6199	0.8673	0.5582	0.5318	0.5695	0.5142
WK	0.7201	0.5963	1.0000	0.7316	0.3244	0.3278	0.4366	0.4968	0.5473	0.5344	0.9508	0.8455	0.3409	0.3682	0.4310	0.3990
PC	0.6079	0.5743	0.7316	1.0000	0.3959	0.3859	0.3391	0.4997	0.4852	0.4445	0.8533	0.7877	0.3529	0.3704	0.3909	0.3611
NO	0.2751	0.4703	0.3244	0.3959	1.0000	0.6401	0.0470	0.4961	0.2279	0.1452	0.3635	0.4972	0.3705	0.3412	0.2601	0.2371
CS	0.2487	0.3953	0.3278	0.3859	0.6401	1.0000	0.0583	0.4078	0.2212	0.1471	0.3609	0.4448	0.3490	0.3387	0.2584	0.2669
AS	0.5202	0.4004	0.4366	0.3391	0.0470	0.0583	1.0000	0.1966	0.6181	0.6692	0.4253	0.4139	0.2093	0.1703	0.3787	0.3889
MK	0.5542	0.7069	0.4968	0.4997	0.4961	0.4078	0.1966	1.0000	0.4939	0.3696	0.5216	0.8163	0.5163	0.4892	0.5174	0.4675
MC	0.6377	0.6134	0.5473	0.4852	0.2279	0.2212	0.6181	0.4939	1.0000	0.6304	0.5542	0.6436	0.4259	0.3854	0.5743	0.5559
EI	0.6245	0.4868	0.5344	0.4445	0.1452	0.1471	0.6692	0.3696	0.6304	1.0000	0.5326	0.5520	0.2685	0.2373	0.4315	0.4254
VE	0.7213	0.6199	0.9508	0.8533	0.3635	0.3609	0.4253	0.5216	0.5542	0.5326	1.0000	0.8860	0.3624	0.3874	0.4401	0.4077
AFQT	0.7488	0.8673	0.8455	0.7877	0.4972	0.4448	0.4139	0.8163	0.6436	0.5520	0.8860	1.0000	0.5309	0.5272	0.5762	0.5261
CT	0.3684	0.5582	0.3409	0.3529	0.3705	0.3490	0.2093	0.5163	0.4259	0.2685	0.3624	0.5309	1.0000	0.6288	0.5530	0.5700
SM	0.3606	0.5318	0.3682	0.3704	0.3412	0.3387	0.1703	0.4892	0.3854	0.2373	0.3874	0.5272	0.6288	1.0000	0.4939	0.4885
ID	0.5024	0.5695	0.4310	0.3909	0.2601	0.2584	0.3787	0.5174	0.5743	0.4315	0.4401	0.5762	0.5530	0.4939	1.0000	0.6461
AO	0.4743	0.5142	0.3990	0.3611	0.2371	0.2669	0.3889	0.4675	0.5559	0.4254	0.4077	0.5261	0.5700	0.4885	0.6461	1.0000
T1	-0.2882	-0.2956	-0.2440	-0.2272	-0.2008	-0.1967	-0.2589	-0.2608	-0.3677	-0.2659	-0.2514	-0.3083	-0.3787	-0.3162	-0.3808	-0.3801
T2	-0.3405	-0.3369	-0.2967	-0.2614	-0.1910	-0.2104	-0.3230	-0.2806	-0.4362	-0.3233	-0.2989	-0.3527	-0.3889	-0.3343	-0.4061	-0.4276
FR	0.5026	0.5945	0.4727	0.4425	0.3073	0.2872	0.3108	0.5457	0.5313	0.3914	0.4854	0.6162	0.5586	0.5422	0.5930	0.5768
SO	0.4888	0.5366	0.4392	0.3930	0.2250	0.2380	0.3955	0.4824	0.5622	0.4291	0.4480	0.5592	0.5067	0.4584	0.5736	0.5779
TI	-0.3151	-0.2651	-0.2537	-0.2224	-0.1781	-0.1917	-0.2274	-0.2300	-0.3216	-0.2349	-0.2563	-0.2916	-0.2964	-0.2807	-0.3287	-0.3664
MEMORY	0.4039	0.6040	0.3928	0.4007	0.3944	0.3811	0.2104	0.5571	0.4496	0.2803	0.4154	0.5862	0.9032	0.9017	0.5802	0.5866
SPATIAL	0.5384	0.5973	0.4575	0.4145	0.2741	0.2895	0.4230	0.5429	0.6230	0.4723	0.4673	0.6076	0.6189	0.5415	0.9078	0.9066
TRACKING	-0.3359	-0.3379	-0.2889	-0.2611	-0.2093	-0.2175	-0.3109	-0.2892	-0.4296	-0.3149	-0.2940	-0.3532	-0.4101	-0.3475	-0.4204	-0.4316
AORT	0.0506	0.1016	0.0590	0.0673	-0.0007	-0.0094	0.0188	0.1322	0.0809	0.0611	0.0642	0.1084	0.1809	0.0781	0.1581	0.2767
IDCT	0.0472	0.0877	0.0550	0.0867	0.0532	0.0315	-0.0154	0.1427	0.0614	0.0413	0.0704	0.1098	0.1465	0.0584	0.2535	0.1030
IDDT	-0.1860	-0.1750	-0.1758	-0.1536	-0.1357	-0.1489	-0.1692	-0.1264	-0.1822	-0.1570	-0.1785	-0.1889	-0.0994	-0.1507	-0.1239	-0.1257
SORT	-0.0330	-0.0013	-0.0216	-0.0040	-0.0385	-0.0516	-0.0699	0.0316	-0.0421	-0.0256	-0.0176	0.0011	0.0559	-0.0203	0.0415	0.0707
FRRT	0.0362	0.0830	0.0540	0.0700	-0.0182	-0.0243	-0.0242	0.1270	0.0483	0.0461	0.0609	0.0994	0.0517	-0.0427	0.1187	0.0706
AO-1	0.4043	0.4577	0.3399	0.3186	0.2016	0.2229	0.3192	0.4382	0.4794	0.3641	0.3513	0.4693	0.5281	0.4416	0.5718	0.8592
AO-2	0.4339	0.4541	0.3640	0.3212	0.2169	0.2496	0.3666	0.3949	0.5045	0.3882	0.3690	0.4636	0.4834	0.4258	0.5750	0.9095

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table B-2 (continued)

VARIABLE	T1	T2	FR	SO	TI	MEMORY	SPATIAL	TRACKING	AORT	IDCT	IDDT	SORT	FRRT	AO-1	AO-2
MEAN	2827.3	3722.98	0.6113	0.4447	1.9156	-0.2824	-0.3184	0.1801	18.3497	12.1886	2.9240	13.9463	18.4711	0.5842	0.5266
STD	406.0732	494.5723	0.2106	0.2726	0.6219	1.1104	1.1287	1.0517	5.5418	5.1455	0.7869	3.8673	4.6202	0.2135	0.2448
GS	-0.2882	-0.3405	0.5026	0.4888	-0.3151	0.4039	0.5384	-0.3359	0.0506	0.0472	-0.1860	-0.0330	0.0362	0.4043	0.4339
AR	-0.2956	-0.3369	0.5945	0.5366	-0.2651	0.6040	0.5973	-0.3379	0.1016	0.0877	-0.1750	-0.0013	0.0830	0.4577	0.4541
WK	-0.2440	-0.2967	0.4727	0.4392	-0.2537	0.3928	0.4575	-0.2889	0.0590	0.0550	-0.1758	-0.0216	0.0540	0.3399	0.3640
PC	-0.2272	-0.2614	0.4425	0.3930	-0.2224	0.4007	0.4145	-0.2611	0.0673	0.0867	-0.1536	-0.0040	0.0700	0.3186	0.3212
NO	-0.2008	-0.1910	0.3073	0.2250	-0.1781	0.3944	0.2741	-0.2093	-0.0007	0.0532	-0.1357	-0.0385	-0.0182	0.2016	0.2169
CS	-0.1967	-0.2104	0.2872	0.2380	-0.1917	0.3811	0.2895	-0.2175	-0.0094	0.0315	-0.1489	-0.0516	-0.0243	0.2229	0.2496
AS	-0.2589	-0.3230	0.3108	0.3955	-0.2274	0.2104	0.4230	-0.3109	0.0188	-0.0154	-0.1692	-0.0699	-0.0242	0.3192	0.3666
MK	-0.2608	-0.2806	0.5457	0.4824	-0.2300	0.5571	0.5429	-0.2892	0.1322	0.1427	-0.1264	0.0316	0.1270	0.4382	0.3949
MC	-0.3677	-0.4362	0.5313	0.5622	-0.3216	0.4496	0.6230	-0.4296	0.0809	0.0614	-0.1822	-0.0421	0.0483	0.4794	0.5045
EI	-0.2659	-0.3233	0.3914	0.4291	-0.2349	0.2803	0.4723	-0.3149	0.0611	0.0413	-0.1570	-0.0256	0.0461	0.3641	0.3882
VE	-0.2514	-0.2989	0.4854	0.4480	-0.2563	0.4154	0.4673	-0.2940	0.0642	0.0704	-0.1785	-0.0176	0.0609	0.3513	0.3690
AFQT	-0.3083	-0.3527	0.6162	0.5592	-0.2916	0.5862	0.6076	-0.3532	0.1084	0.1098	-0.1889	0.0011	0.0994	0.4693	0.4636
CT	-0.3787	-0.3889	0.5586	0.5067	-0.2964	0.9032	0.6189	-0.4101	0.1809	0.1465	-0.0994	0.0559	0.0517	0.5281	0.4834
SM	-0.3162	-0.3343	0.5422	0.4583	-0.2807	0.9017	0.5415	-0.3475	0.0781	0.0584	-0.1507	-0.0203	-0.0427	0.4416	0.4258
ID	-0.3808	-0.4061	0.5930	0.5736	-0.3287	0.5802	0.9078	-0.4204	0.1581	0.2535	-0.1239	0.0415	0.1187	0.5718	0.5750
AO	-0.3801	-0.4276	0.5768	0.5779	-0.3664	0.5866	0.9066	-0.4316	0.2767	0.1030	-0.1257	0.0707	0.0706	0.8592	0.9095
T1	1.0000	0.7522	-0.3464	-0.3668	0.3631	-0.3851	-0.4194	0.9356	-0.1056	-0.1043	0.0750	-0.0174	-0.0562	-0.3398	-0.3340
T2	0.7522	1.0000	-0.3713	-0.4084	0.3844	-0.4008	-0.4594	0.9364	-0.1109	-0.0512	0.1243	0.0002	-0.0329	-0.3776	-0.3797
FR	-0.3464	-0.3713	1.0000	0.5431	-0.2939	0.6099	0.6448	-0.3834	0.1670	0.1646	-0.1223	0.0401	0.1348	0.5260	0.4992
SO	-0.3668	-0.4084	0.5431	1.0000	-0.2815	0.5348	0.6346	-0.4142	0.1563	0.1279	-0.1387	0.0406	0.0738	0.5205	0.5060
TI	0.3631	0.3844	-0.2939	-0.2815	1.0000	-0.3197	-0.3830	0.3993	0.0808	0.0667	0.1615	0.1134	0.1329	-0.2771	-0.3658
MEMORY	-0.3851	-0.4008	0.6099	0.5348	-0.3197	1.0000	0.6431	-0.4199	0.1437	0.1137	-0.1384	0.0199	0.0052	0.5375	0.5039
SPATIAL	-0.4194	-0.4594	0.6448	0.6346	-0.3830	0.6431	1.0000	-0.4695	0.2394	0.1967	-0.1375	0.0618	0.1044	0.7882	0.8176
TRACKING	0.9356	0.9364	-0.3834	-0.4142	0.3993	-0.4199	-0.4695	1.0000	-0.1157	-0.0830	0.1065	-0.0092	-0.0476	-0.3833	-0.3813
AORT	-0.1056	-0.1109	0.1670	0.1563	0.0808	0.1437	0.2394	-0.1157	1.0000	0.3133	0.2186	0.4782	0.4723	0.4274	0.0878
IDCT	-0.1043	-0.0512	0.1646	0.1279	0.0667	0.1137	0.1967	-0.0830	0.3133	1.0000	0.4455	0.3211	0.4605	0.1737	0.0189
IDDT	0.0750	0.1243	-0.1223	-0.1387	0.1615	-0.1384	-0.1375	0.1065	0.2186	0.4455	1.0000	0.2950	0.3620	-0.0542	-0.1625
SORT	-0.0174	0.0002	0.0401	0.0406	0.1134	0.0199	0.0618	-0.0092	0.4782	0.3211	0.2950	1.0000	0.4314	0.1586	-0.0196
FRRT	-0.0562	-0.0329	0.1348	0.0738	0.1329	0.0052	0.1044	-0.0476	0.4723	0.4605	0.3620	0.4314	1.0000	0.1691	-0.0271
AO-1	-0.3398	-0.3776	0.5260	0.5205	-0.2771	0.5375	0.7882	-0.3833	0.4274	0.1737	-0.0542	0.1586	0.1691	1.0000	0.5742
AO-2	-0.3340	-0.3797	0.4992	0.5060	-0.3658	0.5039	0.8176	-0.3813	0.0878	0.0189	-0.1625	-0.0196	-0.0271	0.5742	1.0000

Other ECAT Exploratory Measures

AORT = AO Arithmetic Mean Item Response Latency
IDCT = ID Geometric Mean Component Latency
IDDT = ID Geometric Mean Decision Latency
SORT = SO Arithmetic Mean Item Response Latency
FRRT = FR Arithmetic Mean Item Response Latency
AO-1 = AO Proportion Correct of First 15 Items (Semi-mechanical)
AO-2 = AO Proportion Correct of Final 17 Items (Jig-saw)

Appendix C

Factor Loadings and Scoring Weights

Table C- 1

Promax Oblique Factor Pattern Loadings for ASVAB Tests

Test	Technical	Verbal	Clerical	Math
General Science (GS)	30	46*	-8	25
Arithmetic Reasoning (AR)	20	10	13	57*
Word Knowledge (WK)	3	95*	-1	-5
Paragraph Comprehension (PC)	2	68*	14	4
Numerical Operations (NO)	-1	-3	79*	11
Coding Speed (CS)	1	7	76*	-4
Auto-Shop Information (AS)	96*	-4	3	-17
Mathematical Knowledge (MK)	-8	1	4	90*
Mechanical Comprehension (MC)	60*	3	-1	30
Electronics Information (EI)	70*	11	-2	5

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery.
2. Printed values are multiplied by 100 and rounded to the nearest integer. * Values greater than 0.391348 have been flagged by an '*' by the SAS program automatically.

Table C- 2

Promax Oblique Factor Pattern Loadings for ECAT Tests

Test	Space	Psychomotor	Memory
Mental Counters (CT)	36	-5	45*
Sequential Memory (SM)	6	0	82*
Integrating Details (ID)	78*	-2	1
Assembling Objects (AO)	79*	-4	0
One-hand Tracking (T1)	1	84*	-3
Two-hand Tracking (T2)	-4	87*	2
Figural Reasoning (FR)	58*	0	22
Spatial Orientation (SO)	64*	-7	5
Target Identification (TI)	-22	29	-4

Note. 1. ECAT = Enhanced Computer Administered Testing.
2. Printed values are multiplied by 100 and rounded to the nearest integer * Values greater than 0.415805 have been flagged by an '*' by the SAS program automatically.

Table C- 3

Promax Oblique Factor Pattern Loadings for the Combined ASVAB and ECAT Battery

Test	Reasoning	Technical	Verbal	Psychomotor	Clerical	Math	Space
General Science (GS)	2	23	50*	-3	-5	19	7
Arithmetic Reasoning (AR)	32*	21	11	5	9	42*	-14
Word Knowledge (WK)	2	3	95*	-1	-2	-8	-2
Paragraph Comprehension (PC)	4	3	71*	1	13	0	-5
Numerical Operations (NO)	-4	1	-3	-2	80*	16	-2
Coding Speed (CS)	5	-1	8	-1	75*	-7	8
Auto-Shop Information (AS)	0	101*	-4	2	2	-19	-4
Mathematical Knowledge (MK)	21	-11	4	1	10	71*	-2
Mechanical Comprehension (MC)	19	50*	6	-7	-2	16	8
Electronics Information (EI)	-3	67*	14	0	0	6	2
Mental Counters (CT)	81*	-1	-6	-4	5	-1	-5
Sequential Memory (SM)	80*	-5	8	-1	0	-5	-15
Integrating Details (ID)	57*	7	-2	-3	-2	11	26
Assembling Objects (AO)	65*	6	-3	-1	5	-9	42*
One-hand Tracking (T1)	-3	2	2	86*	0	-1	2
Two-hand Tracking (T2)	-1	-4	0	86*	1	0	1
Figural Reasoning (FR)	59*	-1	12	-1	-5	12	8
Spatial Orientation (SO)	48*	14	4	-6	-5	10	14
Target Identification (TI)	-18	-1	-9	28	-8	11	-15

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.
2. Printed values are multiplied by 100 and rounded to the nearest integer. * Values greater than 0.281284 have been flagged by an '*' by the SAS program automatically.

Table C- 4

Factor Scoring Weights for ASVAB Tests

Test	1st P.C.	G	Tech	Verbal	Clerical	Math
General Science (GS)	0.160683	0.124446	0.133155	0.129648	-0.057020	0.112672
Arithmetic Reasoning (AR)	0.159335	0.146021	0.081161	0.035249	0.084910	0.249897
Word Knowledge (WK)	0.157517	0.323136	0.021085	0.666432	0.012406	-0.014665
Paragraph Comprehension (PC)	0.149042	0.096288	0.003873	0.162562	0.085677	0.028766
Numerical Operations (NO)	0.099969	0.041851	-0.036032	0.006235	0.523072	0.061948
Coding Speed (CS)	0.093965	0.015380	-0.014673	0.021730	0.352370	-0.002553
Auto-Shop Information (AS)	0.116956	-0.028556	0.460053	-0.026813	-0.025900	-0.070284
Mathematical Knowledge (MK)	0.140915	0.285771	-0.034976	0.022025	0.071517	0.556523
Mechanical Comprehension (MC)	0.150609	0.078880	0.216210	0.018429	-0.012580	0.122707
Electronics Information (EI)	0.138763	0.038099	0.237005	0.033869	-0.028370	0.023542

Note. ASVAB = Armed Services Vocational Aptitude Battery.

Table C- 5

Factor Scoring Weights for ECAT Tests

Test	1st P. C.	G	Space	Motor	Memory
Mental Counters (CT)	0.165977	0.128933	0.120076	-0.019311	0.213172
Sequential Memory (SM)	0.153585	0.136731	0.045455	-0.004377	0.649339
Integrating Details (ID)	0.169586	0.227111	0.284949	-0.013117	0.016019
Assembling Objects (AO)	0.171295	0.239514	0.299980	-0.028144	0.011417
One-hand Tracking (T1)	-0.139523	-0.040399	-0.002292	0.395484	-0.023413
Two-hand Tracking (T2)	-0.146363	-0.075038	-0.037161	0.538013	0.010827
Figural Reasoning (FR)	0.164337	0.155273	0.178162	-0.002159	0.099054
Spatial Orientation (SO)	0.160100	0.141189	0.173487	-0.014118	0.025063
Target Identification (TI)	-0.112932	-0.033752	-0.036392	0.048906	-0.005721

Note. ECAT = Enhanced Computer Administered Testing.

Table C- 6

Factor Scoring Weights for the Combined ASVAB + ECAT Battery

Test	1st P. C.	G	Reason	Tech	Verbal	Motor	Clerical	Math	Space
GS	0.090579	0.116335	-0.034671	0.111760	0.161069	-0.022415	-0.055684	0.162183	0.185986
AR	0.096290	0.130532	0.128058	0.080836	0.040947	0.030155	0.065727	0.278467	-0.202079
WK	0.085628	0.149597	-0.008025	0.012588	0.608242	0.005813	0.014046	-0.045200	-0.022326
PC	0.080589	0.051041	0.009681	0.002968	0.173970	0.006195	0.081571	0.011507	-0.058461
NO	0.056952	0.022474	0.003039	-0.023324	0.006026	-0.015418	0.528277	0.067475	-0.105927
CS	0.054997	-0.001776	0.022181	-0.023014	0.024441	-0.010357	0.353765	-0.052457	-0.002383
AS	0.065821	0.050973	-0.021986	0.497251	-0.027584	-0.008116	-0.026905	-0.095979	0.004112
MK	0.086100	0.169459	0.053638	-0.016666	0.039568	0.018550	0.058531	0.487683	0.022571
MC	0.092277	0.098669	0.027074	0.183168	0.029127	-0.032932	-0.040648	0.125279	0.160677
EI	0.076877	0.067393	-0.040685	0.205582	0.044227	-0.000405	-0.028735	0.075567	0.096809
CT	0.081635	0.031194	0.265625	-0.031717	-0.030791	-0.021858	0.055230	-0.054647	-0.183917
SM	0.076796	0.021827	0.246721	-0.046320	0.007499	-0.009879	0.039513	-0.077266	-0.254183
ID	0.088906	0.068834	0.118889	0.030635	-0.006643	-0.015380	-0.033802	0.066089	0.250892
AO	0.086896	0.062514	0.159494	0.033105	-0.014639	-0.018382	-0.004921	-0.023972	0.474977
T1	-0.062314	-0.049516	-0.021145	0.003902	0.010864	0.427301	-0.010019	0.007525	0.025159
T2	-0.068199	-0.061412	-0.015797	-0.028762	0.006100	0.494301	-0.007478	0.021261	-0.015228
FR	0.088221	0.057712	0.131330	0.000021	0.022948	-0.004831	-0.024276	0.050549	0.042384
OR	0.085175	0.047980	0.084762	0.033637	0.001384	-0.014488	-0.031107	0.043616	0.097557
TI	-0.053969	-0.009628	-0.016264	-0.001558	-0.010262	0.047934	-0.018351	0.023192	-0.066429

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

2. For each battery, "G" refers the second-order factor in a hierarchical factor analysis, and 1st P. C. is the first principal component.

3. First-order factor weights are those printed by the SAS FACTOR procedure. They are the result of multiplying the oblique factor structure matrix by the inverse of the correlation matrix of tests.

4. Weights for G were computed by multiplying the pattern matrix for G in terms of tests by the inverse of the test inter-correlation matrix. (The pattern matrix for "G" in terms of tests was computed by multiplying the pattern matrix for G in terms of first-order factors by the first-order pattern matrix.)

5. Factor scores are computed by applying the weights to the test z-scores, i.e. $Factor\ Score = \sum_{i=1}^{tests} W_i \frac{(X_i - \overline{X}_i)}{\sigma_i}$. where the means and standard deviations are range-corrected values taken from Table B-2.

Appendix D

Test Scoring and Subject Deletion Rules

Test Scoring and Subject Deletion Rules

David L. Alderton

For Mental Counters, Integrating Details, Figural Reasoning, Assembling Objects, and Spatial Orientation the final summary score was the proportion correct of the total number of items. For Sequential Memory, the final score was the proportion of digits correct (of all possible).

Subject deletion rules were by and large empirically based. For Mental Counters and Sequential Memory, Jerry Larson provided the cut scores. For Integrating Details, David Alderton provided the cut scores. For all three of these tests, the score cut values were based on the ECAT database and past empirical research. For Figural Reasoning, Assembling Objects, and Spatial Orientation the cut scores were set by David Alderton since AIR and ARI said that there were no established cut score rules or subject screening algorithms. The conservative cut scores for these tests were based on logic (subjects attempting less than 1/3 of the items were eliminated) and empirical score distributions. Cut scores for the three response pedestal tests were provided by AIR (see notes).

Mental Counters

MCPCOR < .19
MCPAT < .75
[redacted]

Sequential Memory

SMPDCOR < .15
SMPIAT < .65

Integrating Details

IDJP > 9
IDPAT < .75
IDPCOR/IDPCAT < .38

Figural Reasoning

SRPAT < .33
SRPCOR < (2.5/30)

Assembling Objects

AOPAT < (11/32)
AOPCOR < (2.75/32)

Spatial Orientation

ORPAT < (8/24)
ORPCOR < (2/24)

Target Identification (see attached notes on scoring response pedestal tests)

Items that time out are treated as valid but wrong,
Items with Decision Times < .1 are treated as invalid,
Items with Movement Times < .01 are treated as invalid.
If the proportion of VALID items correct < 1/3 the subject is eliminated

One- and Two-Hand Tracking (see attached notes on scoring response pedestal tests)

If two (or more) items are missing the subject is eliminated.

Notes on Response Pedestal Tests

The following is a comment from the SAS file ARI.SAS on the ECAT (193) IBM disk. The comments are self-explanatory. I developed the scoring code based on conversations with Scott Oppler and Dianne Steele. After writing the SAS code, I scored the same data they did (Fort Knox, I believe), faxed them the descriptive statistics, and they notified me that our results were in perfect agreement. I later gave this information (and my SAS code) to RGI who used it to create the .merge files.

```
/*============================================================*/
/*  THESE NOTES ARE BASED ON A 4/17/92 CONVERSATION WITH      */
/*  SCOTT OPPLER AND DIANNE STEELE FROM AIR ON HOW THE        */
/*  TARGET IDENTIFICATION TEST SHOULD BE SCORED AND HOW       */
/*  PEOPLE SHOULD BE SCREENED.  THERE IS ALSO A NOTE ON       */
/*  SCREENING SUBJECTS FOR THE TRACKING TESTS                 */
/*============================================================*/
/*                    TARGET IDENTIFICATION                   */
/*                    ^^^^^^^^^^^^^^^^^^^^^                   */
/*  THE TEST SHOULD BE SCORED IN THE FOLLOWING STEPS:         */
/*    A. IF AN ITEM TIMES OUT, SET THE MT, DT SET TO MISS     */
/*          BUT SET AC TO WRONG                               */
/*    B. IF AC IS WRONG, SET MT AND DT TO MISSING             */
/*    C. IF DT IS < .1 THEN SET DT, MT, ACC TO MISSING        */
/*    D. IF MT IS < .01 THEN SET DT, MT, ACC TO MISSING       */
/*    E. IF RECALCULATED ACCURACY IS < 1/3 THEN SET FINAL     */
/*          SCORES TO MISSING                                 */
/*                                                            */
/*                         FINAL SCORES                       */
/*                         ^^^^^^^^^^^^                       */
/*  PROPORTION CORRECT (AFTER SCREENS)                        */
/*  MEDIAN MT ACROSS ALL VALID, CORRECT ITEMS                 */
/*  AVERAGE OF THE CLIPPED EASY MEAN DT AND THE               */
/*        CLIPPED HARD MEAN DT:                               */
/*   (1) AFTER ABOVE SCREENS, SORT ITEMS BY EASY AND HARD     */
/*   (2) THROUGH OUT THE MIN AND MAX DTS WITHIN A GROUP       */
/*   (3) CALCULATE THE (CLIPPED) W/I GROUP MEAN               */
/*   (4) AVERAGE THE TWO CLIPPED MEANS = MDT                  */
/*                                                            */
/*  FOLLOWING THE THREE PRACTICE ITEMS, THE EASY AND ITEM     */
/*      (ORDINAL) POSITIONS ARE:                              */
/*  EASY ITEMS ARE: 1, 3, 5, 6, 7, 10, 13, 14, 15, 17, 18,    */
/*                  19, 23, 26, 27, 28, 30, 32, 34, 36        */
/*  HARD ITEMS ARE: 2, 4, 8, 9, 11, 12, 16, 20, 21, 22, 24,   */
/*                  25, 29, 31, 33, 35                        */
/*============================================================*/
/*               1 AND 2 HAND TRACKING TESTS                  */
/*               ^^^^^^^^^^^^^^^^^^^^^^^^^^^                  */
/*  DROP SUBJECTS THAT HAVE MORE THAN 2 MISSING ITEMS         */
/*  SCOTT AND DIANNE THINK THAT THE AVERAGE OF THE ITEM LEVEL*/
/*    SCORES, I.E., THE AVERAGE OF THE LOG[(RMS DIST) + 1],   */
/*    IS BEING TRUNCATED IN ECAT, SO I'LL RECALCULATE IT      */
/*============================================================*/
```

Appendix E

Test/Retest Results for the ECAT Battery

Test/Retest Results for the ECAT Battery[1]

Gerald E. Larson
David L. Alderton

There are several reasons why it is critical to conduct a test-retest analysis of new tests. First, the reliability coefficient can be used to disattenuate correlations between predictor and criterion measures, providing a better estimate of the true relationship. Second, reliability is often a consideration in decisions regarding test implementation. Third, retest studies provide information on practice effects and perhaps even on coachability. For these reasons the ECAT battery was administered twice across 4- to 5-week intervals. The details of the study are presented below.

Method

Subjects

While it would have been optimal to test military recruits, military scheduling considerations made recruit testing impractical for the current research. Thus, high school and junior college students in the San Diego vicinity were recruited as subjects, with the restrictions that subjects must be between the ages of 16 and 26, with the total sample having no more than 35% females and no less than 60% caucasians. The purpose of these restrictions was to ensure comparability between the sample and military recruits. As an incentive to participate in the study, each subject was paid $15.00 for each test session plus a $40.00 bonus upon completing the retest session and submitting a copy of the subjects' high school transcripts. Further details of the data collection are provided in Brantner (1992).

Three hundred and thirteen subjects (223 males, 90 females) completed both test sessions. They averaged 19.3 years-of-age, with a standard deviation of 2.8. The ethnic breakdown was as follows: 73% Caucasian, 10% Hispanic, 6% Asian, 4% Filipino, 3% African-American, 4% "Other."

---

[1] Presented at the Centennial Convention of the American Psychological Association; Washington, D. C., August 1992

Aptitude Tests

Each subject completed an approximately 3-hour battery of 10 computerized tests, presented on Hewlett-Packard Integral microcomputers operating under UNIX™. Nine of the 10 tests comprised the actual ECAT battery. The tenth, "Perceptual Speed," was included as a supplemental measure about which information was desired. All tests were written in standard C. Tests 1-7 below used a simplified keyboard. The keyboard was modified by using a plastic mask that revealed only the designated response keys along with a key labeled HELP that could be pressed during testing to suspend the program and request assistance. The S, F, H, K, and ; keys were relabeled as: A, B, C, D, and E. The space bar was relabeled ENTER. The numeric keypad keys retained their meanings. Tests 8-10 below (Target Identification, One-hand Tracking, and Two-hand Tracking) used a custom built "response pedestal" with response buttons, sliders, and a joy stick.

1. Integrating Details - A complex 40 item spatial problem solving test. Each item consists of two separate screens. The first screen contains from 2 to 6 regular geometric puzzle pieces that must be mentally brought together to form a completed object. This is much like a jig-saw puzzle. Having connected all of the puzzle pieces, the individual must remember the final object, then press a response key indicating that she/he is ready. Once the key is pressed, the puzzle pieces are replaced by a new screen with a single completed object. The subject must indicate if the completed object shown is a product of the original puzzle pieces. There are three dependent measures for each trial; time spent studying the puzzle pieces, time spent deciding if the completed form is valid, and response accuracy.

2. Mental Counters - Mental Counters is a complex 40 item working memory test. Each screen contains three horizontal lines, arrayed left to right. Each line represents a counter with an initial value of zero. During an item, boxes appear sequentially, one at a time, either above or below one of the three lines. If a box appears above a line, the value for that counter is incremented by +1. If a box appears below a line, that counter is decremented by -1. On each trial either 5 or 7 boxes appear. The boxes appear at one of two rates, either one every 1.33 seconds or one every .75 seconds. The subject's task is to make a series of rapid calculations and to select, from a four-alternative multiple choice menu, the set of correct final counter values. Number of correct responses is used as the summary score.

3. Sequential Memory - Sequential Memory is another complex test of working memory. Each item consists of three to five horizontally arrayed dots on the screen. Each dot is given a numerical value; these must be memorized. The item is then presented in a series of 5 to 7 "calls" to the dots; where each call is announced by briefly turning one of the dots into an "X." The person must report the digit string that corresponds to the order that the dots were "called." In the second half of the test, after all the calls for an item have been made, the examinee is told to translate each number in the ordered number list into a different number and then type in the new ordered list. There are 10 items in the first half of the test and 25 in the second half of the test. The dependent variable is the proportion

of digits correctly reported by the examinee.

4. Spatial Reasoning - A figural inductive reasoning (or series extrapolation) test, similar to the Cognitive Abilities Figural subtests. Items use a combination of geometric forms and arbitrary figures presented in a series of four frames. The subject's task is to induce the transformation rule controlling the series and then select one of five alternatives that correctly completes the series. The dependent variable is number correct across the 30 items. There is a 12 minute time limit.

5. Perceptual Speed - Perceptual Speed (Alderton, 1990) is a clerical/perceptual speed test. Each item consists of two side-by-side symbol strings of the same length. The examinee's task is to determine whether the two symbol strings are identical, and to make these judgements as rapidly as possible while maintaining 90% accuracy. Symbol string length is systematically varied from 1 to 7 elements. The test is divided into 3 subtests based on string content: Numbers (56 items), letters (56 items), or abstract stick figures (60 items). Each item type (number of elements X symbol type) has a minimum and maximum response time bracket associated with it. If an examinee responds too quickly or too slowly she/he is warned to slow down or speed up. Cumulative accuracy is retained and used in feedback after every 10-14 items. To control for speed/accuracy tradeoffs, the examinee is warned to slow down if accuracy drops below 85% or to speed up if accuracy goes above 95%. The primary dependent variable is the average rate score across the three subtests where rate is defined as the proportion correct divided by the geometric mean of item reaction times.

6. Assembling Objects - A spatial construction test. Each item consists of a frame with several (2-6) separate elements. The subject's task is to choose, from four alternatives, the answer that correctly represents how the elements should be connected. There are 32 items in the test. The first 15 items are semi-mechanical items with labels indicating how the elements should be connected. The final 17 items in the test consist of small jigsaw puzzles similar to those used in the Minnesota Paper Form Board test. There are no labels showing how the puzzle pieces are to be connected but only one of the four answer choices includes all of the puzzle elements. The dependent variable is the number of correct items solved in 16 minutes.

7. Spatial Orientation - A spatial perspective test. Each item consists of an environmental view, such as a bridge over a river or a farm house. In each view the horizon is apparent. These views are rotated away from the "natural" horizon in a frame. At the bottom of the frame is a circle with a dot on the perimeter. The subject's task is to rotate the frame around the view until it corresponds with the natural horizon of the view and determine where the dot on the circle would be located. This information is then used to select which of 5 alternatives correctly shows where the dot would be on the circle (following the rotation). The dependent variable is the number of items (of 24) solved correctly in the allotted time.

The next 3 tests use the ECAT response pedestal to input responses.

8. Target Identification - A hybrid test combining aspects of choice reaction time and spatial mental rotation tests. Each item consists of a figure in the top half of the screen and three alternative figures in the bottom half of the screen. The correct answer is the alternative (at screen bottom) that represents the same object as the standard, even though the standard may be distorted (e.g., rotated, shrunken, or both) relative to the answer choice. (Answer choices are always presented in a "natural" upright position) The examinee's task is to select the correct alternative as rapidly as possible. The figures are schematic line drawings of simple objects, such as trucks, helicopters, and tanks. Before each item the subject is required to hold down 4 "home" buttons, two on the left and two on the right. The "home" buttons are located on the sides and top of the response pedestal in such a way that one must use thumbs and forefingers to hold the buttons down, thus freezing the hands in place. While all four buttons are simultaneously depressed the item is presented. As soon as the examinee decides upon an answer, either hand may be used to press the button (on the top of the pedestal) that corresponds to the selected alternative. As soon as any of the four "home" buttons are released the alternatives are masked (blacked out). The dependent variable is the average correct decision time where decision time is defined as the time between item presentation and "home" button release. There are 36 items administered with a maximum 7 minute total test time.

9. One-Hand Tracking - A psychomotor test that uses a response pedestal. Each item begins with a "path" on the computer screen. The path is simply a contiguous string of lighted screen pixels. The path goes up/down and/or right/left, parallel with the sides of the screen and makes only 90 degree turns. At one end of the path is a diamond indicating the path's termination point. Starting at the other end is a box that travels forward along the path. The subject moves a joy-stick that controls the movement of a "cross-hair." The subject's task is to keep the cross-hair on the moving box. Items vary in terms of the length of the path which is inversely related to the speed at which the box moves (total item duration is thus constant). For each item, the "score" is the average absolute Cartesian pixel distance between the cross-hair and the moving box (a distance reading is taken every 50 msec during the item). There are 18 items. The dependent variable for the test is the average of the 18 item scores.

10. Two-Hand Tracking - Another psychomotor test that has exactly the same structure and task constraints as One-Hand Tracking described above. The only difference is that movement of the cross-hair is controlled by two slide potentiometers. One of the slides controls the horizontal (left/right) movement of the cross-hair while the second slide controls the vertical (up/down) motion of the cross hair. One hand must be used for each slide control. The slides are arranged such that the horizontal slide's physical movement is right and left while the vertical slide's physical movement is up and down. Number of items, test scoring, and final test score are the same as above.

Two test administration sequences were used, corresponding to odd and even social security numbers.

Even SSN Sequence	***Odd SSN Sequence***
Sequential Memory	*Integrating Details*
Spatial Reasoning	*Spatial Reasoning*
Integrating Details	*Sequential Memory*
One Hand Tracking	*Two Hand Tracking*
Target Identification	*Target Identification*
Two Hand Tracking	*One Hand Tracking*
Assembling Objects	*Mental Counters*
Spatial Orientation	*Spatial Orientation*
Mental Counters	*Assembling Objects*
Perceptual Speed	*Perceptual Speed*

Perceptual Speed was always administered last because it was not part of the ECAT battery per se.

Results

Prior to the main analyses the data were trimmed to eliminate subjects who scored 10% or more below chance on the power tests. Also, subjects were eliminated if their scores declined 50% or more from session one to session two, or if the score for either session lagged four standard deviations below the sample mean. Finally, speed test scores were discarded if accuracy was below 70%. These data editing rules were designed to eliminate unmotivated or severely impaired examinees. Upon implementing these rules, the proportion of subjects excluded from the analyses ranged from a high of 6% on Assembling Objects and Mental Counters to a low of .3% on One-hand Tracking.

Practice Effects

Descriptive statistics and practice effects for the remaining subjects are shown in Table E-1. As can be seen, practice effects (reflecting improved performance) were significant for all tests except Assembling Objects. Given the relative novelty of the experimental measures, some improvement with practice was to be expected. In many cases, however, improvements were of little practical importance despite statistical significance. For example, note the slight (less than one tenth of a standard deviation) though significant gain for the Integrating Details test. In general, score gains were greatest for speeded and/or psychomotor tests (especially Two-hand Tracking) and it is therefore this category of measures which should be the focus of concern for issues such as practice and coaching.

Table E-1

Descriptive Statistics and Practice Effects

	Session 1		Session 2		Session Difference		
Variable	Mean1	SD1	Mean2	SD2	*t* Value	df	2-tail Prob.
PSRATE	.709	.089	.753	.101	-12.89	308	.000
SEQMEM	.707	.140	.761	.141	-10.76	307	.000
SP_REAS	.692	.199	.733	.175	-5.22	295	.000
INTEGRATE	.773	.132	.784	.128	-2.24	306	.026
ASSEMBLE	.673	.214	.686	.211	-1.77	292	.079
ORIENT	.530	.258	.628	.256	-9.21	294	.000
COUNTERS	.781	.160	.795	.183	-2.04	292	.042
TARGETID	1.66	.568	1.37	.504	14.99	310	.000
TRACK1	2913	432	2777	475	9.35	312	.000
TRACK2	3863	531	3549	619	21.03	309	.000

Reliabilities

Test reliabilities are shown in Table E-2. Retest reliabilities range from .75 to .91, with a median of .81. These figures compare favorably with ASVAB retest reliabilities, which range from .63 to .88, with a median of .79 (Wolfe, in preparation). Internal consistency estimates are also quite acceptable, ranging from .78 to .97 across both sessions. In general, reliabilities were somewhat higher for speeded and/or psychomotor tests that for power tests. Since as noted above the former also showed the greatest practice effects, one may infer that practice caused an upward shift in the psychomotor score distribution without a substantial reordering of individual ranks.

Table E-2

Test Reliabilities

Variable	Session 1 Alpha	Session 2 Alpha	Retest Reliability
PSRATE	.95[a]	.94[a]	.86
SEQMEM	.88	.89	.81
SP_REAS	.87	.86	.75
INTEGRATE	.79	.78	.79
ASSEMBLE	.87	.89	.83
ORIENT	.89	.90	.75
COUNTERS	.89	.91	.79
TARGETID	.97[a]	.97[a]	.80
TRACK1	.97[a]	.97[a]	.84
TRACK2	.97[a]	.97[a]	.91

[a] Split-half reliabilities.

Gender Effects

Table E-3 shows test performance as a function of gender. Females scored significantly below males on five of the ten tests; two of these tests were spatial in nature (Integrating Details and Spatial Orientation) and three were psychomotor (Target ID, One- and Two-hand Tracking). To provide a better context for these findings, it should be noted that there were no gender differences in academic standing (i.e., grade point average) within the sample, nor were there differences on the ECAT reasoning and working memory tests. Therefore, there is no reason to believe that the gender effects reflect underlying general intelligence differences rather than specific spatial and psychomotor differences.

Table E-3

Gender Differences in Test Performance

	Session 1				Session 2				Gender Effect		Gender × Session Effect	
	Males		Females		Males		Females					
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	Prob.	F	Prob.
PSRATE	.707	.092	.716	.082	.750	.104	.760	.092	.76	NS	.07	NS
SEQMEM	.707	.146	.708	.125	.753	.149	.780	.119	.73	NS	5.42	.02
SP_REAS	.700	.209	.674	.175	.734	.185	.731	.151	.41	NS	1.84	NS
INTEGRATE	.791	.130	.729	.128	.791	.131	.766	.121	8.17	.00	12.00	.00
ASSEMBLE	.684	.218	.648	.203	.699	.209	.658	.214	2.22	NS	.07	NS
ORIENT	.565	.264	.444	.221	.662	.257	.545	.234	15.78	.00	.03	NS
COUNTERS	.794	.153	.750	.172	.799	.186	.783	.176	2.18	NS	3.74	NS
TARGETID	1.560	.548	1.910	.536	1.260	.447	1.620	.547	34.69	.00	.00	NS
TRACK1	2778.	378.	3247.	375.	2648.	418.	3096.	457.	91.75	.00	.39	NS
TRACK2	3670.	466.	4334.	359.	3339.	537.	4063.	493.	142.10	.00	3.36	NS

Females: Ns range from 86 to 9.
Males: Ns range from 205 to 223.

Further examination of Table E-3 reveals significant Gender by Session interactions for the Sequential Memory and Integrating Details tests. In both cases the significant interaction reflects the fact that, given practice, females improved substantially more than males on these tests. For Integrating Details, this female score gain served to diminish an initial (i.e, session 1) male advantage. For Sequential Memory, females advanced ahead of males in session 2 after equivalent performance in session 1.

Correlations

Table E-4 shows correlations of the tests with high school grade point average (GPA) and with each other. For this analysis Session 1 and Session 2 scores were averaged to create one global score per test. All variables except Target ID were significantly correlated with GPA. Prediction of GPA would seem to be strongest when based on working memory scores (i.e., Mental Counters and Sequential Memory) and mixed when based on spatial scores, with Integrating Details faring the best in the latter category. The table also shows numerous significant correlations among the experimental tests themselves. The strength and pattern of these test interrelationships is simplified via the factor pattern shown in Table E-5, which shows that the global scores for the nine ECAT tests (ignoring, for the moment, the non-ECAT perceptual speed test) cluster into two dimensions, the first representing cognitive problem solving abilities and the second representing psychomotor skills. When the data from sessions one and two are analyzed separately the same two-factor pattern emerges, suggesting that the pattern shown in Table E-5 is a fairly reliable portrayal of the dimensionality of the ECAT battery, and that limited practice does not overtly change the pattern.

Table E-4

Pearson Correlation Coefficients

	Variable	GPA	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	PSRATE	.20**	1.00								
2.	SEQMEM	.36**	.32**	1.00							
3.	SP_REAS	.30**	.24**	.60**	1.00						
4.	INTEGRATE	.35**	.19**	.58**	.65**	1.00					
5.	ASSEMBLE	.26**	.27**	.62**	.68**	.72**	1.00				
6.	ORIENT	.27**	.14**	.55**	.62**	.67**	.67**	1.00			
7.	COUNTERS	.38**	.35**	.70**	.63**	.64**	.68**	.55**	1.00		
8.	TARGETID	-.07	-.28**	-.23**	-.24**	-.27**	-.33**	-.28**	-.26**	1.00	
9.	TRACK1	-.16**	-.23**	-.33**	-.45**	-.46**	-.43**	-.43**	-.42**	.37**	1.00
10.	TRACK2	-.11*	-.21**	-.33**	-.41**	-.48**	-.46**	-.47**	-.41**	.44**	.84**

* p < .05   ** p < .01

Table E-5

Factor Analysis of ECAT Tests

		Varimax Rotated	
Variable	g Factor	Problem Solving	Psychomotor
SEQMEM	.72	.79	-.09
SP_REAS	.79	.80	-.21
INTEGRATE	.82	.78	-.29
ASSEMBLE	.85	.82	-.29
ORIENT	.78	.75	-.27
COUNTERS	.79	.81	-.19
TARGETID	-.47	-.14	.66
TRACK1	-.67	-.24	.88
TRACK2	-.69	-.27	.89

54% of Variance accounted for by g.

Discussion And Conclusions

Results from our test/retest administration of the ECAT battery are, for the most part, highly encouraging. Test reliabilities are at least as good as those for the operational ASVAB, and although the present study was not specifically designed as a validation effort the correlations of ECAT tests with high school GPA were numerous and highly significant. The latter result supports an optimistic prognosis for test validities in military education and training settings.

Of concern in the present study are the significant practice effects observed for nearly all tests, and the female score deficit observed on some spatial tests and all psychomotor tests. These issues should be addressed by follow-on research prior to operational use of ECAT tests. An important question is whether adding more practice items at the beginning of the tests can stabilize performance prior to the administration of operational items. With regard to gender differences, follow-on analyses must include actual military criterion performance measures. For example, if females under-perform (relative to males) on criterion as well as predictor measures then the latter deficit does not reflect test bias. A finding of gender equivalence on the criteria would, however, suggest that the test is a biased predictor and that alternative tests or administration formats must be sought.

Appendix F

Group Differences in the ECAT Validity Study

Group Differences in the ECAT Validity Study

David L. Alderton

Subjects were divided into six ethnic groups: White, Black, Asian, Hispanic, North American Indian, and Other. The categories are a combination of the population and ethnic group codes taken from enlistment records. White was defined by the population code Caucasian (C) and the ethnic code none (Y). Black was defined by the population code Negroid/African/Black (N) unless a Hispanic ethnic code was also checked (then the person would be defined as Hispanic, see below). The Asian group was defined by the population code Asian/Mongoloid/Yellow (M) and/or ethnic codes for other Asian descent (3), Filipino (5), Chinese (G), Japanese (J), Korean (K), Vietnamese (V), Melanesian (E), Micronesian (W), Polynesian (L), and other Pacific Island descent (Q). Regardless of the population code, the Hispanic group was defined by ethnic codes for other Hispanic descent (1), Puerto Rican (4), Mexican (6), Cuban (9), and Latin American with Hispanic descent (S). The North American Indian group was defined by the population code for American Indian/Red (R) and by ethnic codes for U.S./Canadian Indian Tribes (2), Eskimo (7), and Aleut (8). A final group labeled Other was created from the population code Other (X) and the ethnic codes Other (X) (unless Caucasian), Indian (from India; D), and Unknown (Z). The distribution of subjects across the six ethnic groups was:

Group	*N*	Percent
White	7636	71.1
Black	1771	16.5
Asian	241	2.2
Hispanic	631	5.9
No. Am. Indian	85	0.8
Other/Unknown	369	3.4
Total	10733	100

For the analyses that follow, the North American Indian group was eliminated because the sample size was too small to be meaningful. The Other category was also eliminated since the results could not be interpreted.

Entries in the following table were computed in several steps. First, for each of the 10 ASVAB tests and 9 ECAT tests, z-scores were computed by taking the first named ethnic group's mean minus the second named ethnic group's mean, divided by the standard deviation from the total sample. Second, the within test battery median, mean, minimum, maximum, and range of z-scores were computed: these are the entries in the Table. For example, the first entry (.727) is the median z-score advantage of Whites (since it is positive) over Blacks across the ten

ASVAB tests. For the ECAT tests, the median advantage of Whites over Blacks is .656 z-score units. (Note that for the ECAT tests, the three response pedestal tests [Target Identification, One- and Two-Hand Tracking] use speed and error scores so the sign of these z-scores were reflected to properly indicate which group had the advantage before descriptive statistics were calculated.)

		Median	Mean	Minimum	Maximum	Range
White minus	ASVAB	.727	.588	.023	1.106	1.083
Black	ECAT	.656	.615	.445	.729	.284
White minus	ASVAB	.367	.289	-.396	.829	1.225
Asian	ECAT	.139	.144	-.100	.400	.508
White minus	ASVAB	.314	.299	-.017	.638	.655
Hispanic	ECAT	.116	.137	.026	.248	.222
Black minus	ASVAB	-.246	-.299	-.566	.020	.586
Asian	ECAT	-.443	-.470	-.756	-.085	.671
Black minus	ASVAB	-.320	-.288	-.486	-.001	.467
Hispanic	ECAT	-.539	-.478	-.615	-.197	.418
Asian minus	ASVAB	-.002	.011	-.224	.379	.603
Hispanic	ECAT	.087	-.007	-.266	.189	.455

Paying close attention to the sign of the z-scores reveals several facts about the test batteries and ethnic groups. Whites outperform all ethnic groups on both batteries, but the median ethnic difference is higher for ASVAB than ECAT in all cases. All ethnic groups outperformed Blacks on both test batteries. While the ECAT battery produces a smaller median advantage for Whites over the other ethnic groups in comparison with the ASVAB, ECAT does produce slightly larger differences among Black, Asian, and Hispanic groups relative to one another (and the ASVAB). That is, ECAT reduces the advantage of the majority group (White) but it increases the differentiation among minority groups. However, concerns over adverse impact and group differences invariably focus only on majority-minority comparisons.

In terms of individual tests within the ASVAB, clearly the largest consistent differences appear for Auto-Shop Information where Whites have an advantage ranging from 1.106 to .638 standard deviation units over the other groups. The ASVAB math tests provided the largest advantage for Asians over Black (Arithmetic Reasoning) and Hispanic (Math Knowledge) groups. The largest Hispanic advantage over Blacks was also for the Auto-Shop Information test. For the individual ECAT tests, no one test consistently differentiated any of the groups across the six comparisons. Indeed, six different tests produced the largest z-score difference in the six comparisons.

More detailed information follow these pages. The next two pages contain the variable names and descriptions used in the analyses. The variables include years of education, educational level, and dominant language as demographics, then test scores from the ASVAB and ECAT batteries. Following that are the six pairwise group comparison analyses (White-Black, White-Asian, White-Hispanic, Black-Asian, Black-Hispanic, Asian-Hispanic). Each group comparison is contained in a two-page table. The ASVAB variables included the ten subtest standard scores, AFQT, and VE. For the ECAT tests, at least the following variables were looked at: time spent in instructions, time spent on the test, average item response times, proportion of items attempted, and proportion correct. Generally, the results converge: if a group does less well on proportion correct, they spent more time in the instructions and in the test, had longer item response times, and when there was variation in the number of items attempted, they attempted fewer. The nine ECAT scores that should be focused on are: IDPCOR (Integrating Details Proportion Correct), MCPCOR (Mental Counters Proportion Correct), ORPCOR (Spatial Orientation Proportion Correct), SMPDCOR (Sequential Memory Proportion of Digits Correct), SRPCOR (Spatial/Figural Reasoning Proportion Correct), AOPCOR (Assembling Objects Proportion Correct), TIDDT (Target Identification Decision Time), T1MN (One-Hand Tracking Mean 1000*Log(1+RMS); a distance off-target measure, i.e., an error score), and T2MN (Two-Hand Tracking error score).

The remaining pages of this letter report consist of:

A. List of the variables and their abbreviations used in the analyses (2 pages, F4-F5)

B. White vs. Black comparisons (2 pages, F6-F7)

C. White vs. Asian comparisons (2 pages, F8-F9)

D. White vs. Hispanic comparisons (2 pages, F10-F11)

E. Black vs. Asian comparisons (2 pages, F12-F13)

F. Black vs. Hispanic comparisons (2 pages, F14-F15)

G. Asian vs. Hispanic comparisons (2 pages, F16-F17)

Variable	Variable Description
YRSED	YEARS OF EDUCATION
EDLEV	EDUCATION LEVEL
LANG	LANGUAGE
AFQT1	PRE-ENLISTMENT AFQT PERCENTILE SCORE
GS1	PRE-ENLISTMENT GS STANDARD SCORE
AR1	PRE-ENLISTMENT AR STANDARD SCORE
WK1	PRE-ENLISTMENT WK STANDARD SCORE
PC1	PRE-ENLISTMENT PC STANDARD SCORE
NO1	PRE-ENLISTMENT NO STANDARD SCORE
CS1	PRE-ENLISTMENT CS STANDARD SCORE
AS1	PRE-ENLISTMENT AS STANDARD SCORE
MK1	PRE-ENLISTMENT MK STANDARD SCORE
MC1	PRE-ENLISTMENT MC STANDARD SCORE
EI1	PRE-ENLISTMENT EI STANDARD SCORE
VE1	PRE-ENLISTMENT VE STANDARD SCORE
IDIT	ID INSTRUCTION TIME (IN SECONDS)
IDTT	ID TESTING TIME (IN SECONDS)
IDDT	ID GEOMETRIC MEAN DECISION LATENCY
IDCT	ID GEOMETRIC MEAN COMPONENT LATENCY
IDPAT	ID PROPORTION OF ITEMS ATTEMPTED
IDPCOR	ID PROPORTION OF TEST ITEMS CORRECT
MCIT	MC INSTRUCTION TIME (IN SECONDS)
MCTT	MC TESTING TIME (IN SECONDS)
MCRT	MC ARITHMETIC MEAN ITEM RESPONSE LATENCY
MCPAT	MC PROPORTION OF ITEMS ATTEMPTED
MCPCOR	MC PROPORTION OF ITEMS CORRECT
ORIT	OR INSTRUCTION TIME (IN SECONDS)
ORTT	OR TESTING TIME (IN SECONDS)
ORRT	OR ARITHMETIC MEAN ITEM RESPONSE LATENCY
ORPAT	OR PROPORTION OF ITEMS ATTEMPTED
ORPCOR	OR PROPORTION OF ITEMS CORRECT

Variable	Variable Description
SMIT	SM INSTRUCTION TIME (IN SECONDS)
SMTT	SM TESTING TIME (IN SECONDS)
SMRT	SM AVERAGE ITEM RESPONSE LATENCY
SMPIAT	SM PROPORTION OF DIGITS ATTEMPTED
SMPICOR	SM PROPORTION WITH ALL 5 DIGITS CORRECT
SMPDCOR	SM PROPORTION DIGITS ENTERED CORRECTLY
SRIT	SR INSTRUCTION TIME (IN SECONDS)
SRTT	SR TESTING TIME (IN SECONDS)
SRRT	SR ARITHMETIC MEAN ITEM RESPONSE LATENCY
SRPAT	SR PROPORTION OF TEMS ATTEMPTED
SRPCOR	SR PROPORTION OF TEST ITEMS CORRECT
AOIT	AO INSTRUCTION TIME (IN SECONDS)
AOTT	AO TESTING TIME (IN SECONDS)
AORT	AO ARITHMETIC MEAN ITEM RESPONSE LATENCY
AOPAT	AO PROPORTION OF ITEMS ATTEMPTED
AOPCOR	AO PROPORTION OF ALL ITEMS CORRECT
TIDIT	TID INSTRUCTION TIME (IN SECONDS)
TIDTT	TID TESTING TIME (IN SECONDS)
TIDAT	TARGET ID NUMBER OF VALID ATTEMPTS
TIDCOR	TARGET ID NUMBER OF VALID ITEMS CORRECT
TIDDT	TARGET ID MEAN CLIPPED DECISION RTS
TIDMT	TARGET ID MEDIAN VALID MOVEMENT TIME
T1IT	TR1 INSTRUCTION TIME (IN SECONDS)
T1TT	TR1 TESTING TIME (IN SECONDS)
T1NAT	TRACK1 NUMBER VALID ITEM ATTEMPTS
T1MN	TRACK1 MEAN 1000*LOG(1+RMS(ATTEMPTED))
T1RMS	TRACK1 AVERAGE RMS DISTANCE OFF TARGET
T1SD	TRACK1 SD OF 1000*LOG(1+RMS(ATTEMPTED))
T2IT	TR2 INSTRUCTION TIME (IN SECONDS)
T2TT	TR2 TESTING TIME (IN SECONDS)
T2NAT	TRACK2 NUMBER VALID/SCORED ITEM ATTEMPTS
T2MN	TRACK2 MEAN 1000*LOG(1+RMS(ATTEMPTED))
T2RMS	TRACK2 AVERAGE RMS DISTANCE OFF TARGET
T2SD	TRACK2 SD OF 1000*LOG(1+RMS(ATTEMPTED))

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Black Mean	Black SD	Black *N*	Z	t
YRSED	11.947	0.843	10728	11.944	0.860	7634	11.993	0.703	1769	-0.058	-2.230
EDLEV	1.939	0.665	10389	1.941	0.672	7388	1.921	0.607	1718	0.030	1.131
LANG	1.047	0.333	10389	1.022	0.240	7388	1.020	0.209	1718	0.006	0.318
AFQT1	60.291	18.004	10705	63.289	17.751	7615	50.032	15.192	1765	0.736	29.009
GS1	52.901	7.435	10704	54.364	6.936	7614	48.280	7.067	1765	0.818	33.085
AR1	53.310	6.943	10705	54.400	6.779	7615	49.173	6.119	1765	0.753	29.709
WK1	52.866	5.377	10705	53.883	4.880	7615	49.926	5.463	1765	0.736	29.988
PC1	53.091	5.740	10705	53.779	5.408	7615	50.822	6.082	1765	0.515	20.201
NO1	54.077	6.629	10705	54.083	6.610	7615	53.930	6.779	1765	0.023	0.872
CS1	53.095	6.926	10705	53.274	6.861	7615	52.293	7.246	1765	0.142	5.355
AS1	53.479	8.059	10706	55.626	7.372	7616	46.714	6.398	1765	1.106	46.862
MK1	54.816	6.926	10706	54.967	7.194	7616	53.834	6.011	1765	0.164	6.138
MC1	54.613	7.745	10706	56.165	7.358	7616	49.188	6.802	1765	0.901	36.395
EI1	52.310	7.917	10706	53.609	7.657	7616	47.913	7.224	1765	0.719	28.455
VE1	53.041	5.113	10706	53.992	4.669	7616	50.234	5.111	1765	0.735	29.915
IDIT	415.618	124.096	10386	399.628	110.441	7387	466.671	152.415	1717	-0.540	-20.943
IDTT	883.350	329.687	10386	852.722	306.326	7387	957.900	379.784	1717	-0.319	-12.212
IDDT	2.886	0.806	10383	2.787	0.696	7384	3.207	1.017	1717	-0.521	-20.441
IDCT	12.582	5.737	10383	12.139	5.154	7384	13.590	7.180	1717	-0.253	-9.684
IDPAT	0.995	0.038	10383	0.997	0.028	7384	0.989	0.061	1717	0.211	8.163
IDPCOR	0.754	0.129	9668	0.771	0.123	6893	0.677	0.126	1576	0.729	27.246
MCIT	316.175	86.308	10386	304.433	75.190	7388	359.543	113.640	1715	-0.639	-24.538
MCTT	583.965	72.991	10386	575.217	67.243	7388	617.073	86.139	1715	-0.573	-21.936
MCRT	5.026	1.591	2760	4.870	1.449	2116	5.773	1.959	327	-0.568	-9.952
MCPAT	1.00	0.015	10382	1.00	0.012	7385	0.999	0.024	1715	0.067	2.485
MCPCOR	0.718	0.180	10300	0.739	0.172	7338	0.621	0.184	1689	0.656	25.084
ORIT	302.231	92.953	10389	290.645	87.810	7388	341.029	100.075	1718	-0.542	-20.843
ORTT	340.486	92.540	10389	333.076	87.630	7388	358.716	102.610	1718	-0.277	-10.560
ORRT	14.090	4.000	10384	13.752	3.728	7384	14.942	4.597	1718	-0.297	-11.371
ORPAT	0.999	0.016	10384	0.999	0.013	7384	0.997	0.025	1718	0.125	4.675
ORPCOR	0.510	0.248	10200	0.544	0.247	7294	0.372	0.198	1652	0.694	26.444

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Black Mean	Black SD	Black *N*	Z	t
SMIT	435.323	200.754	10387	403.400	177.446	7387	537.521	223.650	1717	-0.668	-26.766
SMTT	959.016	146.053	10386	938.342	131.968	7387	1018.79	159.099	1717	-0.551	-21.840
SMRT	1.717	0.661	2762	1.621	0.560	2118	2.034	0.832	327	-0.625	-11.519
SMPIAT	0.997	0.029	10383	0.999	0.024	7385	0.994	0.038	1717	0.172	6.862
SMPICOR	0.436	0.184	10383	0.455	0.184	7385	0.374	0.172	1717	0.440	16.630
SMPDCOR	0.683	0.137	10348	0.697	0.134	7362	0.636	0.142	1710	0.445	16.765
SRIT	163.657	71.791	10386	154.186	64.014	7385	193.363	87.179	1718	-0.546	-21.203
SRTT	574.197	118.696	10386	564.277	117.913	7385	599.163	119.241	1718	-0.294	-11.022
SRRT	18.812	4.883	10385	18.350	4.489	7384	20.080	5.758	1718	-0.354	-13.584
SRPAT	0.984	0.062	10389	0.988	0.053	7388	0.969	0.085	1718	0.306	11.755
SRPCOR	0.658	0.194	10338	0.682	0.185	7356	0.576	0.200	1706	0.546	20.991
AOIT	214.630	68.918	10387	208.183	66.369	7387	234.964	76.975	1717	-0.389	-14.594
AOTT	599.530	138.005	10387	596.453	134.946	7387	597.908	155.889	1717	-0.011	-0.390
AORT	18.748	5.812	10386	18.404	5.231	7387	19.649	7.780	1717	-0.214	-8.015
AOPAT	0.972	0.082	10386	0.980	0.067	7387	0.944	0.124	1717	0.439	16.614
AOPCOR	0.620	0.195	10378	0.646	0.190	7384	0.507	0.179	1712	0.713	27.566
TIDIT	126.386	38.638	10389	121.976	35.381	7388	138.735	44.758	1718	-0.434	-16.761
TIDTT	158.130	42.534	10389	153.760	37.574	7388	172.077	51.540	1718	-0.431	-16.853
TIDAT	31.442	6.825	10361	31.207	6.887	7373	32.347	6.425	1709	-0.167	-6.242
TIDCOR	29.791	7.133	10361	29.630	7.135	7373	30.352	7.011	1709	-0.101	-3.781
TIDDT	1.857	0.625	10365	1.791	0.570	7379	2.094	0.737	1708	-0.485	-18.655
TIDMT	0.350	0.150	10365	0.341	0.135	7379	0.380	0.194	1708	-0.260	-9.821
T1IT	184.165	45.812	10389	180.307	42.331	7388	195.618	54.597	1718	-0.334	-12.731
T1TT	225.515	7.996	10389	225.480	7.667	7388	225.380	6.414	1718	0.013	0.501
T1NAT	17.992	0.320	10387	17.989	0.379	7388	17.999	0.034	1717	-0.031	-1.092
T1MN	2772.92	402.89	10381	2728.97	368.572	7382	2956.49	479.32	1717	-0.565	-21.669
T1RMS	18.881	11.867	10381	17.688	10.291	7382	23.843	15.893	1717	-0.519	-19.877
T1SD	383.731	113.471	10381	379.052	110.989	7382	412.109	126.899	1717	-0.291	-10.807
T2IT	141.582	36.627	10389	139.589	34.919	7388	148.125	42.535	1718	-0.233	-8.737
T2TT	225.550	8.916	10389	225.479	7.842	7388	225.814	11.607	1718	-0.038	-1.441
T2NAT	17.995	0.223	10385	17.994	0.243	7386	17.994	0.219	1717	0.000	0.000
T2MN	3645.07	476.94	10380	3579.64	457.75	7382	3913.79	469.53	1716	-0.701	-27.106
T2RMS	49.067	23.462	10380	45.771	21.448	7382	62.701	26.843	1716	-0.722	-27.997
T2SD	415.329	89.205	10380	414.958	88.966	7382	420.915	90.341	1716	-0.067	-2.491

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Asian Mean	Asian SD	Asian *N*	Z	t
YRSED	11.947	0.843	10728	11.944	0.860	7634	12.187	0.914	241	-0.288	-4.310
EDLEV	1.939	0.665	10389	1.941	0.672	7388	1.765	0.675	234	0.265	3.944
LANG	1.047	0.333	10389	1.022	0.240	7388	1.684	1.247	234	-1.988	-31.007
AFQT1	60.291	18.004	10705	63.289	17.751	7615	57.854	18.959	240	0.302	4.660
GS1	52.901	7.435	10704	54.364	6.936	7614	49.837	8.050	240	0.609	9.903
AR1	53.310	6.943	10705	54.400	6.779	7615	53.100	6.850	240	0.187	2.924
WK1	52.866	5.377	10705	53.883	4.880	7615	49.821	7.412	240	0.755	12.451
PC1	53.091	5.740	10705	53.779	5.408	7615	51.629	7.068	240	0.375	6.000
NO1	54.077	6.629	10705	54.083	6.610	7615	55.333	6.377	240	-0.189	-2.888
CS1	53.095	6.926	10705	53.274	6.861	7615	53.783	6.731	240	-0.073	-1.132
AS1	53.479	8.059	10706	55.626	7.372	7616	48.946	7.202	240	0.829	13.831
MK1	54.816	6.926	10706	54.967	7.194	7616	57.708	6.375	240	-0.396	-5.831
MC1	54.613	7.745	10706	56.165	7.358	7616	52.833	7.350	240	0.430	6.908
EI1	52.310	7.917	10706	53.609	7.657	7616	50.775	8.006	240	0.358	5.638
VE1	53.041	5.113	10706	53.992	4.669	7616	50.392	6.953	240	0.704	11.549
IDIT	415.618	124.096	10386	399.628	110.441	7387	433.209	136.102	234	-0.271	-4.543
IDTT	883.350	329.687	10386	852.722	306.326	7387	957.051	339.782	234	-0.316	-5.111
IDDT	2.886	0.806	10383	2.787	0.696	7384	3.118	1.169	234	-0.411	-6.971
IDCT	12.582	5.737	10383	12.139	5.154	7384	13.573	6.000	234	-0.250	-4.168
IDPAT	0.995	0.038	10383	0.997	0.028	7384	0.993	0.041	234	0.105	2.115
IDPCOR	0.754	0.129	9668	0.771	0.123	6893	0.774	0.124	214	-0.023	-0.351
MCIT	316.175	86.308	10386	304.433	75.190	7388	317.551	67.673	234	-0.152	-2.635
MCTT	583.965	72.991	10386	575.217	67.243	7388	583.667	55.983	234	-0.116	-1.901
MCRT	5.026	1.591	2760	4.870	1.449	2116	5.155	1.202	67	-0.179	-1.593
MCPAT	1.00	0.015	10382	1.00	0.012	7385	1.000	1.000	234	0.000	0.000
MCPCOR	0.718	0.180	10300	0.739	0.172	7338	0.757	0.165	233	-0.100	-1.575
ORIT	302.231	92.953	10389	290.645	87.810	7388	310.051	80.126	234	-0.209	-3.337
ORTT	340.486	92.540	10389	333.076	87.630	7388	369.103	99.403	234	-0.389	-6.165
ORRT	14.090	4.000	10384	13.752	3.728	7384	15.280	4.316	234	-0.382	-6.141
ORPAT	0.999	0.016	10384	0.999	0.013	7384	0.998	0.016	234	0.062	1.149
ORPCOR	0.510	0.248	10200	0.544	0.247	7294	0.503	0.250	225	0.165	2.451

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Asian Mean	Asian SD	Asian *N*	Z	t
SMIT	435.323	200.75	10387	403.40	177.45	7387	469.35	231.4	234	-0.329	-5.538
SMTT	959.02	146.05	10386	938.34	131.97	7387	1027.53	179.78	234	-0.611	-10.047
SMRT	1.717	0.661	2762	1.621	0.560	2118	2.097	0.782	67	-0.720	-6.754
SMPIAT	0.997	0.029	10383	0.999	0.024	7385	0.996	0.018	234	0.103	1.895
SMPICOR	0.436	0.184	10383	0.455	0.184	7385	0.417	0.186	234	0.207	3.109
SMPDCOR	0.683	0.137	10348	0.697	0.134	7362	0.678	0.135	234	0.139	2.135
SRIT	163.657	71.791	10386	154.186	64.014	7385	170.004	74.783	234	-0.220	-3.701
SRTT	574.197	118.696	10386	564.277	117.913	7385	620.799	101.430	234	-0.476	-7.248
SRRT	18.812	4.883	10385	18.350	4.489	7384	20.905	5.448	234	-0.523	-8.511
SRPAT	0.984	0.062	10389	0.988	0.053	7388	0.966	0.085	234	0.355	6.106
SRPCOR	0.658	0.194	10338	0.682	0.185	7356	0.662	0.190	234	0.103	1.627
AOIT	214.630	68.918	10387	208.183	66.369	7387	208.718	54.285	234	-0.008	-0.122
AOTT	599.530	138.005	10387	596.453	134.946	7387	627.496	116.370	234	-0.225	-3.478
AORT	18.748	5.812	10386	18.404	5.231	7387	19.725	4.894	234	-0.227	-3.811
AOPAT	0.972	0.082	10386	0.980	0.067	7387	0.965	0.078	234	0.183	3.354
AOPCOR	0.620	0.195	10378	0.646	0.190	7384	0.644	0.184	234	0.010	0.159
TIDIT	126.386	38.638	10389	121.976	35.381	7388	139.444	52.710	234	-0.452	-7.301
TIDTT	158.130	42.534	10389	153.760	37.574	7388	170.333	56.155	234	-0.390	-6.521
TIDAT	31.442	6.825	10361	31.207	6.887	7373	32.410	6.067	234	-0.176	-2.640
TIDCOR	29.791	7.133	10361	29.630	7.135	7373	30.368	6.863	234	-0.103	-1.559
TIDDT	1.857	0.625	10365	1.791	0.570	7379	2.041	0.729	231	-0.400	-6.502
TIDMT	0.350	0.150	10365	0.341	0.135	7379	0.348	0.121	231	-0.047	-0.778
T1IT	184.165	45.812	10389	180.307	42.331	7388	186.791	45.874	234	-0.142	-2.301
T1TT	225.515	7.996	10389	225.480	7.667	7388	226.850	14.732	234	-0.171	-2.587
T1NAT	17.992	0.320	10387	17.989	0.379	7388	17.996	0.065	234	-0.022	-0.282
T1MN	2772.92	402.89	10381	2728.97	368.572	7382	2846.66	492.87	234	-0.292	-4.752
T1RMS	18.881	11.867	10381	17.688	10.291	7382	21.314	15.028	234	-0.306	-5.217
T1SD	383.731	113.471	10381	379.052	110.989	7382	368.839	93.150	234	0.090	1.392
T2IT	141.582	36.627	10389	139.589	34.919	7388	141.880	40.535	234	-0.063	-0.983
T2TT	225.550	8.916	10389	225.479	7.842	7388	225.607	4.994	234	-0.014	-0.248
T2NAT	17.995	0.223	10385	17.994	0.243	7386	18.000	1.000	234	-0.027	-0.305
T2MN	3645.07	476.94	10380	3579.64	457.75	7382	3729.56	517.478	234	-0.314	-4.912
T2RMS	49.067	23.462	10380	45.771	21.448	7382	54.010	26.864	234	-0.351	-5.736
T2SD	415.329	89.205	10380	414.958	88.966	7382	396.848	81.750	234	0.203	3.073

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Hispanic Mean	Hispanic SD	Hispanic *N*	Z	t
YRSED	11.947	0.843	10728	11.944	0.860	7634	11.832	0.882	631	0.133	3.138
EDLEV	1.939	0.665	10389	1.941	0.672	7388	2.038	0.749	611	-0.146	-3.398
LANG	1.047	0.333	10389	1.022	0.240	7388	1.100	0.316	611	-0.234	-7.513
AFQT1	60.291	18.004	10705	63.289	17.751	7615	56.620	15.770	631	0.370	9.143
GS1	52.901	7.435	10704	54.364	6.936	7614	50.835	7.439	631	0.475	12.212
AR1	53.310	6.943	10705	54.400	6.779	7615	52.368	6.653	631	0.293	7.246
WK1	52.866	5.377	10705	53.883	4.880	7615	51.024	5.469	631	0.532	14.006
PC1	53.091	5.740	10705	53.779	5.408	7615	52.523	5.891	631	0.219	5.567
NO1	54.077	6.629	10705	54.083	6.610	7615	53.937	6.651	631	0.022	0.533
CS1	53.095	6.926	10705	53.274	6.861	7615	52.922	6.722	631	0.051	1.240
AS1	53.479	8.059	10706	55.626	7.372	7616	50.488	7.884	631	0.638	16.733
MK1	54.816	6.926	10706	54.967	7.194	7616	55.086	5.607	631	-0.017	-0.405
MC1	54.613	7.745	10706	56.165	7.358	7616	52.758	7.411	631	0.440	11.171
EI1	52.310	7.917	10706	53.609	7.657	7616	50.889	7.983	631	0.344	8.547
VE1	53.041	5.113	10706	53.992	4.669	7616	51.477	5.194	631	0.492	12.887
IDIT	415.618	124.096	10386	399.628	110.441	7387	439.551	127.728	610	-0.322	-8.473
IDTT	883.350	329.687	10386	852.722	306.326	7387	976.003	352.798	610	-0.374	-9.437
IDDT	2.886	0.806	10383	2.787	0.696	7384	2.985	0.836	610	-0.246	-6.642
IDCT	12.582	5.737	10383	12.139	5.154	7384	14.050	6.056	610	-0.333	-8.676
IDPAT	0.995	0.038	10383	0.997	0.028	7384	0.994	0.040	610	0.079	2.448
IDPCOR	0.754	0.129	9668	0.771	0.123	6893	0.756	0.128	568	0.116	2.785
MCIT	316.175	86.308	10386	304.433	75.190	7388	328.637	86.239	611	-0.280	-7.557
MCTT	583.965	72.991	10386	575.217	67.243	7388	590.666	63.689	611	-0.212	-5.479
MCRT	5.026	1.591	2760	4.870	1.449	2116	5.380	1.674	169	-0.321	-4.350
MCPAT	1.00	0.015	10382	1.00	0.012	7385	1.000	1.000	611	0.000	0.000
MCPCOR	0.718	0.180	10300	0.739	0.172	7338	0.723	0.169	609	0.089	2.209
ORIT	302.231	92.953	10389	290.645	87.810	7388	319.291	92.960	611	-0.308	-7.714
ORTT	340.486	92.540	10389	333.076	87.630	7388	359.624	96.764	611	-0.287	-7.137
ORRT	14.090	4.000	10384	13.752	3.728	7384	14.883	4.185	611	-0.283	-7.136
ORPAT	0.999	0.016	10384	0.999	0.013	7384	0.999	0.016	611	0.000	0.000
ORPCOR	0.510	0.248	10200	0.544	0.247	7294	0.502	0.242	600	0.169	4.010

Variable	All Mean	All SD	All *N*	White Mean	White SD	White *N*	Hispanic Mean	Hispanic SD	Hispanic *N*	Z	t
SMIT	435.323	200.754	10387	403.400	177.446	7387	467.337	212.544	611	-0.318	-8.421
SMTT	959.016	146.053	10386	938.342	131.968	7387	1008.76	181.026	611	-0.482	-12.270
SMRT	1.717	0.661	2762	1.621	0.560	2118	2.157	0.948	169	-0.811	-11.229
SMPIAT	0.997	0.029	10383	0.999	0.024	7385	0.995	0.036	611	0.138	3.783
SMPICOR	0.436	0.184	10383	0.455	0.184	7385	0.406	0.172	611	0.266	6.357
SMPDCOR	0.683	0.137	10348	0.697	0.134	7362	0.663	0.129	609	0.248	6.035
SRIT	163.657	71.791	10386	154.186	64.014	7385	181.805	75.943	611	-0.385	-10.094
SRTT	574.197	118.696	10386	564.277	117.913	7385	602.339	107.123	611	-0.321	-7.720
SRRT	18.812	4.883	10385	18.350	4.489	7384	19.880	5.223	611	-0.313	-7.989
SRPAT	0.984	0.062	10389	0.988	0.053	7388	0.980	0.067	611	0.129	3.507
SRPCOR	0.658	0.194	10338	0.682	0.185	7356	0.644	0.199	606	0.196	4.831
AOIT	214.630	68.918	10387	208.183	66.369	7387	231.556	65.740	611	-0.339	-8.372
AOTT	599.530	138.005	10387	596.453	134.946	7387	627.923	120.847	611	-0.228	-5.582
AORT	18.748	5.812	10386	18.404	5.231	7387	19.773	5.603	611	-0.236	-6.182
AOPAT	0.972	0.082	10386	0.980	0.067	7387	0.968	0.083	611	0.146	4.171
AOPCOR	0.620	0.195	10378	0.646	0.190	7384	0.627	0.189	611	0.097	2.376
TIDIT	126.386	38.638	10389	121.976	35.381	7388	135.245	39.609	611	-0.343	-8.824
TIDTT	158.130	42.534	10389	153.760	37.574	7388	163.565	52.452	611	-0.231	-5.986
TIDAT	31.442	6.825	10361	31.207	6.887	7373	31.895	6.361	609	-0.101	-2.383
TIDCOR	29.791	7.133	10361	29.630	7.135	7373	30.328	6.669	609	-0.098	-2.332
TIDDT	1.857	0.625	10365	1.791	0.570	7379	1.903	0.642	610	-0.179	-4.617
TIDMT	0.350	0.150	10365	0.341	0.135	7379	0.354	0.161	610	-0.087	-2.250
T1IT	184.165	45.812	10389	180.307	42.331	7388	193.735	50.769	611	-0.293	-7.413
T1TT	225.515	7.996	10389	225.480	7.667	7388	226.173	8.811	611	-0.087	-2.121
T1NAT	17.992	0.320	10387	17.989	0.379	7388	18.000	0.000	611	-0.034	-0.717
T1MN	2772.92	402.89	10381	2728.97	368.57	7382	2739.36	377.28	611	-0.026	-0.668
T1RMS	18.881	11.867	10381	17.688	10.291	7382	17.930	10.687	611	-0.020	-0.557
T1SD	383.731	113.471	10381	379.052	110.989	7382	368.924	103.953	611	0.089	2.178
T2IT	141.582	36.627	10389	139.589	34.919	7388	147.383	35.167	611	-0.213	-5.299
T2TT	225.550	8.916	10389	225.479	7.842	7388	226.036	10.923	611	-0.062	-1.630
T2NAT	17.995	0.223	10385	17.994	0.243	7386	18.000	1.000	611	-0.027	-0.394
T2MN	3645.07	476.94	10380	3579.64	457.75	7382	3633.37	450.9	611	-0.113	-2.792
T2RMS	49.067	23.462	10380	45.771	21.448	7382	47.986	21.651	611	-0.094	-2.451
T2SD	415.329	89.205	10380	414.958	88.966	7382	410.716	92.755	611	0.048	1.129

Variable	All Mean	All SD	All *N*	Black Mean	Black SD	Black *N*	Asian Mean	Asian SD	Asian *N*	Z	t
YRSED	11.947	0.843	10728	11.993	0.703	1769	12.187	0.914	241	-0.230	-3.863
EDLEV	1.939	0.665	10389	1.921	0.607	1718	1.765	0.675	234	0.235	3.637
LANG	1.047	0.333	10389	1.020	0.209	1718	1.684	1.247	234	-1.994	-20.122
AFQT1	60.291	18.004	10705	50.032	15.192	1765	57.854	18.959	240	-0.434	-7.247
GS1	52.901	7.435	10704	48.280	7.067	1765	49.837	8.050	240	-0.209	-3.147
AR1	53.310	6.943	10705	49.173	6.119	1765	53.100	6.850	240	-0.566	-9.190
WK1	52.866	5.377	10705	49.926	5.463	1765	49.821	7.412	240	0.020	0.266
PC1	53.091	5.740	10705	50.822	6.082	1765	51.629	7.068	240	-0.141	-1.890
NO1	54.077	6.629	10705	53.930	6.779	1765	55.333	6.377	240	-0.212	-3.029
CS1	53.095	6.926	10705	52.293	7.246	1765	53.783	6.731	240	-0.215	-3.014
AS1	53.479	8.059	10706	46.714	6.398	1765	48.946	7.202	240	-0.277	-4.992
MK1	54.816	6.926	10706	53.834	6.011	1765	57.708	6.375	240	-0.559	-9.299
MC1	54.613	7.745	10706	49.188	6.802	1765	52.833	7.350	240	-0.471	-7.712
EI1	52.310	7.917	10706	47.913	7.224	1765	50.775	8.006	240	-0.362	-5.682
VE1	53.041	5.113	10706	50.234	5.111	1765	50.392	6.953	240	-0.031	-0.428
IDIT	415.618	124.096	10386	466.671	152.415	1717	433.209	136.102	234	0.270	3.189
IDTT	883.350	329.687	10386	957.900	379.784	1717	957.051	339.782	234	0.003	0.032
IDDT	2.886	0.806	10383	3.207	1.017	1717	3.118	1.169	234	0.110	1.232
IDCT	12.582	5.737	10383	13.590	7.180	1717	13.573	6.000	234	0.003	0.035
IDPAT	0.995	0.038	10383	0.989	0.061	1717	0.993	0.041	234	-0.105	-0.973
IDPCOR	0.754	0.129	9668	0.677	0.126	1576	0.774	0.124	214	-0.752	-10.587
MCIT	316.175	86.308	10386	359.543	113.640	1715	317.551	67.673	234	0.487	5.520
MCTT	583.965	72.991	10386	617.073	86.139	1715	583.667	55.983	234	0.458	5.768
MCRT	5.026	1.591	2760	5.773	1.959	327	5.155	1.202	67	0.388	2.487
MCPAT	1.00	0.015	10382	0.999	0.024	1715	1.000	1.000	234	-0.067	-0.041
MCPCOR	0.718	0.180	10300	0.621	0.184	1689	0.757	0.165	233	-0.756	-10.704
ORIT	302.231	92.953	10389	341.029	100.075	1718	310.051	80.126	234	0.333	4.541
ORTT	340.486	92.540	10389	358.716	102.610	1718	369.103	99.403	234	-0.112	-1.458
ORRT	14.090	4.000	10384	14.942	4.597	1718	15.280	4.316	234	-0.085	-1.063
ORPAT	0.999	0.016	10384	0.997	0.025	1718	0.998	0.016	234	-0.062	-0.595
ORPCOR	0.510	0.248	10200	0.372	0.198	1652	0.503	0.250	225	-0.528	-8.997

Variable	All Mean	All SD	All *N*	Black Mean	Black SD	Black *N*	Asian Mean	Asian SD	Asian *N*	Z	t
SMIT	435.323	200.754	10387	537.521	223.650	1717	469.350	231.399	234	0.340	4.356
SMTT	959.016	146.053	10386	1018.79	159.099	1717	1027.53	179.776	234	-0.060	-0.775
SMRT	1.717	0.661	2762	2.034	0.832	327	2.097	0.782	67	-0.095	-0.570
SMPIAT	0.997	0.029	10383	0.994	0.038	1717	0.996	0.018	234	-0.069	-0.793
SMPICOR	0.436	0.184	10383	0.374	0.172	1717	0.417	0.186	234	-0.234	-3.552
SMPDCOR	0.683	0.137	10348	0.636	0.142	1710	0.678	0.135	234	-0.307	-4.268
SRIT	163.657	71.791	10386	193.363	87.179	1718	170.004	74.783	234	0.325	3.907
SRTT	574.197	118.696	10386	599.163	119.241	1718	620.799	101.430	234	-0.182	-2.648
SRRT	18.812	4.883	10385	20.080	5.758	1718	20.905	5.448	234	-0.169	-2.069
SRPAT	0.984	0.062	10389	0.969	0.085	1718	0.966	0.085	234	0.048	0.507
SRPCOR	0.658	0.194	10338	0.576	0.200	1706	0.662	0.190	234	-0.443	-6.205
AOIT	214.630	68.918	10387	234.964	76.975	1717	208.718	54.285	234	0.381	5.047
AOTT	599.530	138.005	10387	597.908	155.889	1717	627.496	116.370	234	-0.214	-2.799
AORT	18.748	5.812	10386	19.649	7.780	1717	19.725	4.894	234	-0.013	-0.146
AOPAT	0.972	0.082	10386	0.944	0.124	1717	0.965	0.078	234	-0.256	-2.523
AOPCOR	0.620	0.195	10378	0.507	0.179	1712	0.644	0.184	234	-0.703	-10.944
TIDIT	126.386	38.638	10389	138.735	44.758	1718	139.444	52.710	234	-0.018	-0.222
TIDTT	158.130	42.534	10389	172.077	51.540	1718	170.333	56.155	234	0.041	0.480
TIDAT	31.442	6.825	10361	32.347	6.425	1709	32.410	6.067	234	-0.009	-0.142
TIDCOR	29.791	7.133	10361	30.352	7.011	1709	30.368	6.863	234	-0.002	-0.033
TIDDT	1.857	0.625	10365	2.094	0.737	1708	2.041	0.729	231	0.085	1.027
TIDMT	0.350	0.150	10365	0.380	0.194	1708	0.348	0.121	231	0.213	2.443
T1IT	184.165	45.812	10389	195.618	54.597	1718	186.791	45.874	234	0.193	2.362
T1TT	225.515	7.996	10389	225.380	6.414	1718	226.850	14.732	234	-0.184	-2.676
T1NAT	17.992	0.320	10387	17.999	0.034	1717	17.996	0.065	234	0.009	1.103
T1MN	2772.92	402.89	10381	2956.49	479.32	1717	2846.66	492.87	234	0.273	3.277
T1RMS	18.881	11.867	10381	23.843	15.893	1717	21.314	15.028	234	0.213	2.298
T1SD	383.731	113.471	10381	412.109	126.899	1717	368.839	93.150	234	0.381	5.034
T2IT	141.582	36.627	10389	148.125	42.535	1718	141.880	40.535	234	0.171	2.119
T2TT	225.550	8.916	10389	225.814	11.607	1718	225.607	4.994	234	0.023	0.269
T2NAT	17.995	0.223	10385	17.994	0.219	1717	18.000	1.000	234	-0.027	-0.214
T2MN	3645.07	476.944	10380	3913.79	469.530	1716	3729.56	517.478	234	0.386	5.560
T2RMS	49.067	23.462	10380	62.701	26.843	1716	54.010	26.864	234	0.370	4.646
T2SD	415.329	89.205	10380	420.915	90.341	1716	396.848	81.750	234	0.270	3.865

	All			Black			Hispanic				
Variable	**Mean**	**SD**	***N***	**Mean**	**SD**	***N***	**Mean**	**SD**	***N***	**Z**	**t**
YRSED	11.947	0.843	10728	11.993	0.703	1769	11.832	0.882	631	0.191	4.604
EDLEV	1.939	0.665	10389	1.921	0.607	1718	2.038	0.749	611	-0.176	-3.838
LANG	1.047	0.333	10389	1.020	0.209	1718	1.100	0.316	611	-0.240	-7.028
AFQT1	60.291	18.004	10705	50.032	15.192	1765	56.620	15.770	631	-0.366	-9.255
GS1	52.901	7.435	10704	48.280	7.067	1765	50.835	7.439	631	-0.344	-7.686
AR1	53.310	6.943	10705	49.173	6.119	1765	52.368	6.653	631	-0.460	-10.997
WK1	52.866	5.377	10705	49.926	5.463	1765	51.024	5.469	631	-0.204	-4.332
PC1	53.091	5.740	10705	50.822	6.082	1765	52.523	5.891	631	-0.296	-6.079
NO1	54.077	6.629	10705	53.930	6.779	1765	53.937	6.651	631	-0.001	-0.022
CS1	53.095	6.926	10705	52.293	7.246	1765	52.922	6.722	631	-0.091	-1.907
AS1	53.479	8.059	10706	46.714	6.398	1765	50.488	7.884	631	-0.468	-11.930
MK1	54.816	6.926	10706	53.834	6.011	1765	55.086	5.607	631	-0.181	-4.569
MC1	54.613	7.745	10706	49.188	6.802	1765	52.758	7.411	631	-0.461	-11.047
EI1	52.310	7.917	10706	47.913	7.224	1765	50.889	7.983	631	-0.376	-8.634
VE1	53.041	5.113	10706	50.234	5.111	1765	51.477	5.194	631	-0.243	-5.221
IDIT	415.618	124.096	10386	466.671	152.415	1717	439.551	127.728	610	0.219	3.931
IDTT	883.350	329.687	10386	957.900	379.784	1717	976.003	352.798	610	-0.055	-1.030
IDDT	2.886	0.806	10383	3.207	1.017	1717	2.985	0.836	610	0.275	4.841
IDCT	12.582	5.737	10383	13.590	7.180	1717	14.050	6.056	610	-0.080	-1.414
IDPAT	0.995	0.038	10383	0.989	0.061	1717	0.994	0.040	610	-0.132	-1.885
IDPCOR	0.754	0.129	9668	0.677	0.126	1576	0.756	0.128	568	-0.612	-12.758
MCIT	316.175	86.308	10386	359.543	113.640	1715	328.637	86.239	611	0.358	6.123
MCTT	583.965	72.991	10386	617.073	86.139	1715	590.666	63.689	611	0.362	6.932
MCRT	5.026	1.591	2760	5.773	1.959	327	5.380	1.674	169	0.247	2.222
MCPAT	1.00	0.015	10382	0.999	0.024	1715	1.000	1.000	611	-0.067	-0.041
MCPCOR	0.718	0.180	10300	0.621	0.184	1689	0.723	0.169	609	-0.567	-11.979
ORIT	302.231	92.953	10389	341.029	100.075	1718	319.291	92.960	611	0.234	4.697
ORTT	340.486	92.540	10389	358.716	102.610	1718	359.624	96.764	611	-0.01	-0.191
ORRT	14.090	4.000	10384	14.942	4.597	1718	14.883	4.185	611	0.015	0.279
ORPAT	0.999	0.016	10384	0.997	0.025	1718	0.999	0.016	611	-0.125	-1.847
ORPCOR	0.510	0.248	10200	0.372	0.198	1652	0.502	0.242	600	-0.524	-12.950

Variable	All Mean	All SD	All *N*	Black Mean	Black SD	Black *N*	Hispanic Mean	Hispanic SD	Hispanic *N*	Z	t
SMIT	435.323	200.75	10387	537.521	223.650	1717	467.337	212.544	611	0.350	6.748
SMTT	959.02	146.05	10386	1018.79	159.1	1717	1008.76	181.026	611	0.069	1.290
SMRT	1.717	0.661	2762	2.034	0.832	327	2.157	0.948	169	-0.186	-1.487
SMPIAT	0.997	0.029	10383	0.994	0.038	1717	0.995	0.036	611	-0.034	-0.566
SMPICOR	0.436	0.184	10383	0.374	0.172	1717	0.406	0.172	611	-0.174	-3.949
SMPDCOR	0.683	0.137	10348	0.636	0.142	1710	0.663	0.129	609	-0.197	-4.125
SRIT	163.657	71.791	10386	193.363	87.179	1718	181.805	75.943	611	0.161	2.908
SRTT	574.197	118.696	10386	599.163	119.241	1718	602.339	107.123	611	-0.027	-0.580
SRRT	18.812	4.883	10385	20.080	5.758	1718	19.880	5.223	611	0.041	0.755
SRPAT	0.984	0.062	10389	0.969	0.085	1718	0.980	0.067	611	-0.177	-2.895
SRPCOR	0.658	0.194	10338	0.576	0.200	1706	0.644	0.199	606	-0.351	-7.199
AOIT	214.630	68.918	10387	234.964	76.975	1717	231.556	65.740	611	0.049	0.975
AOTT	599.530	138.005	10387	597.908	155.889	1717	627.923	120.847	611	-0.217	-4.320
AORT	18.748	5.812	10386	19.649	7.780	1717	19.773	5.603	611	-0.021	-0.362
AOPAT	0.972	0.082	10386	0.944	0.124	1717	0.968	0.083	611	-0.293	-4.443
AOPCOR	0.620	0.195	10378	0.507	0.179	1712	0.627	0.189	611	-0.615	-14.016
TIDIT	126.386	38.638	10389	138.735	44.758	1718	135.245	39.609	611	0.090	1.705
TIDTT	158.130	42.534	10389	172.077	51.540	1718	163.565	52.452	611	0.200	3.490
TIDAT	31.442	6.825	10361	32.347	6.425	1709	31.895	6.361	609	0.066	1.495
TIDCOR	29.791	7.133	10361	30.352	7.011	1709	30.328	6.669	609	0.003	0.073
TIDDT	1.857	0.625	10365	2.094	0.737	1708	1.903	0.642	610	0.306	5.677
TIDMT	0.350	0.150	10365	0.380	0.194	1708	0.354	0.161	610	0.173	2.965
T1IT	184.165	45.812	10389	195.618	54.597	1718	193.735	50.769	611	0.041	0.746
T1TT	225.515	7.996	10389	225.380	6.414	1718	226.173	8.811	611	-0.099	-2.364
T1NAT	17.992	0.320	10387	17.999	0.034	1717	18.000	0.000	611	-0.003	-0.727
T1MN	2772.92	402.89	10381	2956.49	479.32	1717	2739.36	377.28	611	0.539	10.135
T1RMS	18.881	11.867	10381	23.843	15.893	1717	17.930	10.687	611	0.498	8.535
T1SD	383.731	113.471	10381	412.109	126.899	1717	368.924	103.953	611	0.381	7.558
T2IT	141.582	36.627	10389	148.125	42.535	1718	147.383	35.167	611	0.020	0.387
T2TT	225.550	8.916	10389	225.814	11.607	1718	226.036	10.923	611	-0.025	-0.412
T2NAT	17.995	0.223	10385	17.994	0.219	1717	18.000	1.000	611	-0.027	-0.233
T2MN	3645.07	476.94	10380	3913.79	469.53	1716	3633.37	450.9	611	0.588	12.809
T2RMS	49.067	23.462	10380	62.701	26.843	1716	47.986	21.651	611	0.627	12.209
T2SD	415.329	89.205	10380	420.915	90.341	1716	410.716	92.755	611	0.114	2.380

Variable	All Mean	All SD	All *N*	Asian Mean	Asian SD	Asian *N*	Hispanic Mean	Hispanic SD	Hispanic *N*	Z	t
YRSED	11.947	0.843	10728	12.187	0.914	241	11.832	0.882	631	0.421	5.262
EDLEV	1.939	0.665	10389	1.765	0.675	234	2.038	0.749	611	-0.411	-4.869
LANG	1.047	0.333	10389	1.684	1.247	234	1.100	0.316	611	1.754	10.721
AFQT1	60.291	18.004	10705	57.854	18.959	240	56.620	15.770	631	0.069	0.974
GS1	52.901	7.435	10704	49.837	8.050	240	50.835	7.439	631	-0.134	-1.729
AR1	53.310	6.943	10705	53.100	6.850	240	52.368	6.653	631	0.105	1.439
WK1	52.866	5.377	10705	49.821	7.412	240	51.024	5.469	631	-0.224	-2.615
PC1	53.091	5.740	10705	51.629	7.068	240	52.523	5.891	631	-0.156	-1.890
NO1	54.077	6.629	10705	55.333	6.377	240	53.937	6.651	631	0.211	2.799
CS1	53.095	6.926	10705	53.783	6.731	240	52.922	6.722	631	0.124	1.688
AS1	53.479	8.059	10706	48.946	7.202	240	50.488	7.884	631	-0.191	-2.640
MK1	54.816	6.926	10706	57.708	6.375	240	55.086	5.607	631	0.379	5.932
MC1	54.613	7.745	10706	52.833	7.350	240	52.758	7.411	631	0.01	0.134
EI1	52.310	7.917	10706	50.775	8.006	240	50.889	7.983	631	-0.014	-0.188
VE1	53.041	5.113	10706	50.392	6.953	240	51.477	5.194	631	-0.212	-2.496
IDIT	415.618	124.096	10386	433.209	136.102	234	439.551	127.728	610	-0.051	-0.634
IDTT	883.350	329.687	10386	957.051	339.782	234	976.003	352.798	610	-0.057	-0.706
IDDT	2.886	0.806	10383	3.118	1.169	234	2.985	0.836	610	0.165	1.840
IDCT	12.582	5.737	10383	13.573	6.000	234	14.050	6.056	610	-0.083	-1.027
IDPAT	0.995	0.038	10383	0.993	0.041	234	0.994	0.040	610	-0.026	-0.323
IDPCOR	0.754	0.129	9668	0.774	0.124	214	0.756	0.128	568	0.140	1.768
MCIT	316.175	86.308	10386	317.551	67.673	234	328.637	86.239	611	-0.128	-1.769
MCTT	583.965	72.991	10386	583.667	55.983	234	590.666	63.689	611	-0.096	-1.477
MCRT	5.026	1.591	2760	5.155	1.202	67	5.380	1.674	169	-0.141	-1.002
MCPAT	1.00	0.015	10382	1.000	0.000	234	1.000	0.000	611	0.000	0.000
MCPCOR	0.718	0.180	10300	0.757	0.165	233	0.723	0.169	609	0.189	2.629
ORIT	302.231	92.953	10389	310.051	80.126	234	319.291	92.960	611	-0.099	-1.341
ORTT	340.486	92.540	10389	369.103	99.403	234	359.624	96.764	611	0.102	1.265
ORRT	14.090	4.000	10384	15.280	4.316	234	14.883	4.185	611	0.099	1.223
ORPAT	0.999	0.016	10384	0.998	0.016	234	0.999	0.016	611	-0.062	-0.813
ORPCOR	0.510	0.248	10200	0.503	0.250	225	0.502	0.242	600	0.004	0.052

Variable	All			Asian			Hispanic				
	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Z	t
SMIT	435.323	200.754	10387	469.350	231.399	234	467.337	212.544	611	0.010	0.120
SMTT	959.016	146.053	10386	1027.52	179.776	234	1008.76	181.026	611	0.128	1.351
SMRT	1.717	0.661	2762	2.097	0.782	67	2.157	0.948	169	-0.091	-0.460
SMPIAT	0.997	0.029	10383	0.996	0.018	234	0.995	0.036	611	0.034	0.406
SMPICOR	0.436	0.184	10383	0.417	0.186	234	0.406	0.172	611	0.060	0.813
SMPDCOR	0.683	0.137	10348	0.678	0.135	234	0.663	0.129	609	0.109	1.492
SRIT	163.657	71.791	10386	170.004	74.783	234	181.805	75.943	611	-0.164	-2.030
SRTT	574.197	118.696	10386	620.799	101.430	234	602.339	107.123	611	0.156	2.274
SRRT	18.812	4.883	10385	20.905	5.448	234	19.880	5.223	611	0.210	2.522
SRPAT	0.984	0.062	10389	0.966	0.085	234	0.980	0.067	611	-0.226	-2.514
SRPCOR	0.658	0.194	10338	0.662	0.190	234	0.644	0.199	606	0.093	1.190
AOIT	214.630	68.918	10387	208.718	54.285	234	231.556	65.740	611	-0.331	-4.732
AOTT	599.530	138.005	10387	627.496	116.370	234	627.923	120.847	611	-0.003	-0.046
AORT	18.748	5.812	10386	19.725	4.894	234	19.773	5.603	611	-0.008	-0.115
AOPAT	0.972	0.082	10386	0.965	0.078	234	0.968	0.083	611	-0.037	-0.478
AOPCOR	0.620	0.195	10378	0.644	0.184	234	0.627	0.189	611	0.087	1.179
TIDIT	126.386	38.638	10389	139.444	52.710	234	135.245	39.609	611	0.109	1.252
TIDTT	158.130	42.534	10389	170.333	56.155	234	163.565	52.452	611	0.159	1.645
TIDAT	31.442	6.825	10361	32.410	6.067	234	31.895	6.361	609	0.075	1.066
TIDCOR	29.791	7.133	10361	30.368	6.863	234	30.328	6.669	609	0.006	0.077
TIDDT	1.857	0.625	10365	2.041	0.729	231	1.903	0.642	610	0.221	2.678
TIDMT	0.350	0.150	10365	0.348	0.121	231	0.354	0.161	610	-0.040	-0.514
T1IT	184.165	45.812	10389	186.791	45.874	234	193.735	50.769	611	-0.152	-1.826
T1TT	225.515	7.996	10389	226.850	14.732	234	226.173	8.811	611	0.085	0.817
T1NAT	17.992	0.320	10387	17.996	0.065	234	18.000	0.000	611	-0.013	-1.523
T1MN	2772.92	402.89	10381	2846.66	492.87	234	2739.36	377.278	611	0.266	3.384
T1RMS	18.881	11.867	10381	21.314	15.028	234	17.930	10.687	611	0.285	3.655
T1SD	383.731	113.471	10381	368.839	93.150	234	368.924	103.953	611	-0.001	-0.011
T2IT	141.582	36.627	10389	141.880	40.535	234	147.383	35.167	611	-0.150	-1.949
T2TT	225.550	8.916	10389	225.607	4.994	234	226.036	10.923	611	-0.048	-0.578
T2NAT	17.995	0.223	10385	18.000	0.000	234	18.000	0.000	611	0.000	0.000
T2MN	3645.07	476.944	10380	3729.56	517.478	234	3633.37	450.897	611	0.202	2.661
T2RMS	49.067	23.462	10380	54.010	26.864	234	47.986	21.651	611	0.257	3.376
T2SD	415.329	89.205	10380	396.848	81.750	234	410.716	92.755	611	-0.155	-2.008

Appendix G

Criterion Data Editing and Outlier Detection

Criterion Data Editing and Outlier Detection

Criteria were of two types: (1) Final School Grades (FSG) and other test scores (such as the FAA exam or the AFPT70 typing test) supplied by the training school, and (2) Composites of more elementary measures of classroom or shop/laboratory performance. For the latter, a contractor (RGI Inc.) collected vast amounts of detailed records of homework, quizzes, tests scores, simulator performance measures, etc. Based on factor analyses, they formed composites of variables loading on the corresponding factors (Kieckhaefer, et al., 1992). In addition, some composites were constructed on rational grounds, e.g. FSG scores in the Army 13F, Air Force APS, and Navy AC schools, were computed rather than taken from school records.

One problem with composites of internal measures is that the curricula change frequently, so that some students do not take tests that other students take. Another problem is that most students are likely to miss a few quizzes or laboratory exercises for a variety of personal reasons. The approach that was adopted for handling the missing data was to define a composite for a given student as equal to the mean of the component measures that were present for that student. Thus a composite criterion that was supposed to consist of 14 test scores would be computed for a student that missed five exams and took only 9 of them, for example. In most cases, the component measures ranged from 0 to 100, but their standard deviations sometimes differed by a factor of two. There was no attempt to scale the tests to have equal means and standard deviations, nor to use regression estimates for the missing values.

The criteria were subjected to a very careful review and multi-stage editing process. The first step was to run a regression analysis for each criterion against all 10 ASVAB tests plus 9 ECAT tests (19 predictors). For each sample point, a DFFITS measure of influence was computed, as described by Belsley, Kuh, and Welsch (1980). The authors estimate the standard deviation of DFFITS to be $\sqrt{p/n}$ and recommend a cutoff of 2 standard deviations for selecting influential observations for further examination. In the ECAT sample, this rule would have produced far too many cases for study; instead we selected cases whose DFFITS values were ±4 standard deviations for further study.

On the first pass, we simply tried omitting all such outliers from the analysis and compared the results with the first regression analyses. The effects of deleting the high influence cases were sometimes quite large, e.g. the multiple correlation for the Army's 13F Final School Grade went from .415 to .597 and the standard error of prediction on a Iackknife cross-validation went from 6.432 to 3.452 when only 5 of 831 cases were deleted. Similarly large changes were found for 13F Firing, 11H(A) EVT2TO, ATC BLK5A, AE SUM2, and RM FSG. Results with the outliers removed were presented by Wolfe(1993, November).

Next, we began an investigation into why the outliers occurred. The approach was to try to find general principles or rules for excluding troublesome cases, and to retain outliers in the data base unless a clear-cut rule could be found for deleting them. The first explanation that turned up was scoring error. Several types of programming errors were detected and corrected:

1. Missing test or performance scores were treated as if they were zeros when summing up criterion composites. This occurred in all criteria for 11H, 13F, and possibly some others.

2. Test scores that were supposed to be in the composite were omitted (AE and ET).

3. Variables that were not supposed to be in the composite were included (AE and ET).

4. Miscellaneous programming errors with unknown effects, if any. These included hanging DO loops without END statements (AV and ET), attempts to compare alphabetic strings with numeric values (AV), and defining an array of variables with the same variable twice (OS).

After rescoring the data, the regression analyses for outlier detection were run again. The data were examined again for possible causes of strange behavior. A large percentage (sometimes all) of the outliers came from students who dropped out of school either because of academic failure or because of administrative reasons, such as bereavement, illness, AWOL, personality difficulties, alcohol, drugs, or disciplinary reasons. The Navy sample included 66 academic dropouts and 314 administrative dropouts. However, no information on student status was available for any Army or Air Force schools, or for the Navy FC or OS schools.

The major reason that dropouts had atypical scores was that their data were incomplete. The administrative drops sometimes had above-average scores on some criteria, and very deviant scores on others. Some of them had FSGs in their records, but based on only the part of the curriculum that they completed. Different schools apparently had different policies for computing these grades: sometimes they were missing, sometimes they were quite high (evidently means of tests completed), and sometimes they were very low (possibly assigning zeros to missing test scores). Even where no dropout codes were available, a frequent characteristic of outliers was very incomplete data regarding test or performance scores. A composite criterion that was supposed to be the mean of 10-14 measures might contain only 1 or 2 of them, for example.

Another, but related, cause of outliers was non-normal criterion distributions arising from binary (Pass/Fail) component scores. For example, in the Air Force ATC school, several criteria were defined as the difference between a binary performance standard score and a standardized measure of time on course section. In other cases, distributional problems arose when the mean of 4 to 12 binary measures was reduced to the mean of only 1 or 2, due to incomplete data.

To improve the quality of the data, the administrative school dropouts were all deleted from the ECAT data base. Next, the number of components going into each composite was tabulated for each student. (These counts were labeled N_FSG, N_ADV, etc.) Rules were formulated that eliminated most of the remaining outliers as follows:

APS Drop cases with N_FSG < 3 out of 6 tests.

AC Drop cases with N_PRF < 2 out of 4 tests.

AV Drop cases if N_ADV + N_PERF < 2 out of 8 tests.

ET Drop cases where MEAN(N_PRF1 , N_PRF2) ≤ 1 out of 10 or 14 tests, respectively.

FC Drop 37 cases with N_RADAR = 0.

Four outliers appeared to be associated with previously undetected problems with their ECAT tests. In ECAT a "jump" is defined as a fast response to a difficult test item. In AMS school, one examinee had 26 jumps in the Mental Counters test and got 27% of the items correct. In OS school, one outlier had 21 jumps in the Figural Reasoning test with only 16.7% correct. In ATC and APS schools, two outliers had high jumps and low scores on the Mental Counters test. These examinees were obviously not trying, but were pressing keys at random. Further examination of the the entire ECAT sample showed that of 19 cases with more than 6 jumps on Figural Reasoning, none scored higher than 50% on the test. On Mental Counters, none of the 73 cases that had more than 15 jumps scored higher than 50% correct. Because some high jump cases scored above chance, it was difficult to formulate a general principle for screening outliers that did not also exclude too many legitimate cases. Thus the four outliers previously identified were retained in the ECAT sample.

In a few remaining outliers, the reasons for their atypical behavior could not be determined. For example, in 11H(B), the EVT1TO, EVT2TO, and EVT3TO scores were each the sum of scores on ten "shots". The individual shots were scored on a scale from 0 to 100. One student received scores of 0 on all ten of his EVT1TO shots and on eight of his EVT2TO shots. He was retained in the ECAT sample, because there was no way of knowing why he behaved as he did. Perhaps he had some basic misconception about the task, perhaps he forgot his glasses that day, perhaps the equipment malfunctioned, etc.

On the final analyses, the policy was to exclude only those cases (and all such cases), that violated some clear-cut principle, regardless of whether they were outliers or not. This policy resulted in excluding many more non-outliers than outliers (e.g. the 314 administrative dropouts) while retaining some outliers for which it was difficult to formulate a rationale for deleting them.

It should be noted that in the majority of academic failures, no Final School Grades were available, and we did not choose to impute scores to these failures. However, knowledge and performance test averages were present in most cases.

As a final check, regression analyses were run with and without the remaining outliers to determine the magnitudes of the effects on multiple correlations. Tables G-1 to G-3 show, with some exceptions, that the remaining outliers have little effect on the multiple correlations, and even less on the differences between ASVAB and ASVAB + ECAT multiple correlations, which are the incremental validities.

Table G-1

Effect of Dropping High Influence Cases on Multiple Correlations
All Army Criteria

School	Criterion	Full N	Outliers Dropped	ASVAB R	ASVAB R-Change	ASVAB+ECAT R	ASVAB+ECAT R-Change	Incremental Validity Change
11H(A)1	TOALL	554	6	.242	.002	.296	-.023	-.026
11H(A)2	EVT1TO	556	1	.316	.012	.365	.014	.001
11H(A)3	EVT2TO	555	0	.242	.000	.294	.000	.000
11H(A)4	EVT3TO	550	1	.294	-.007	.347	-.006	.001
11H(A)5	EVTSUM	546	0	.321	.000	.382	.000	.000
11H(A)6	TO_1	542	4	.210	-.004	.274	-.003	.001
11H(B)1	TOALL	320	4	.313	-.061	.364	-.052	.009
11H(B)2	EVT1TO	320	0	.291	.000	.416	.000	.000
11H(B)3	EVT2TO	319	1	.312	.006	.442	-.005	-.011
11H(B)4	EVT3TO	319	1	.234	-.007	.301	-.009	-.003
11H(B)5	EVTSUM	316	1	.330	.016	.456	.001	-.015
11H(B)6	TO_1	319	0	.144	.000	.327	.000	.000
11H(B)7	TO_2	320	0	.172	.000	.311	.000	.000
11H(B)8	TO_3	319	2	.176	-.013	.340	.009	.022
11H(B)9	ITVTOW	318	0	.154	.000	.354	.000	.000
13F1	FSG	821	0	.544	.000	.598	.000	.000
13F2	MPRAD	821	2	.513	.006	.591	-.002	-.009
13F3	FIRING	821	0	.444	.000	.472	.000	.000
19K1	COMM	1158	19	.080	.005	.142	-.009	-.015
19K2	WEAPON	1325	9	.187	-.005	.211	.000	.005
19K3	LANDNAV	1192	15	.175	-.012	.198	-.011	.001
19K4	LOADER	1313	2	.066	.007	.092	.005	-.003
19K5	MAINT	1329	6	.128	.017	.163	.004	-.013
19K6	NBC	1313	11	.119	-.023	.142	-.013	.010
19K7	AVERAGE	1106	7	.208	-.003	.227	.008	.010

Table G-2

Effect of Dropping High Influence Cases on Multiple Correlations
All Air Force Criteria

		Full	Outliers	ASVAB		ASVAB+ECAT		Incremental
School	Criterion	N	Dropped	R	R-Change	R	R-Change	Validity Change
APS1	FSG	446	1	.545	.003	.585	.005	.003
APS2	ZHRS	446	2	.424	.011	.487	.004	-.008
APS3	AFPT70	432	3	.294	-.000	.422	.000	.001
APS5	BYPAS1	369	2	.296	.024	.394	.002	-.022
APS6	FINAL	369	2	.296	.024	.394	.002	-.022
APS7	DWPM	357	3	.213	.037	.244	.036	-.001
ATC1	FSG	484	2	.403	.008	.451	.009	.000
ATC2	BLK2	349	0	.374	.000	.421	.000	.000
ATC3	BLK3A	529	9	.153	.013	.229	.004	-.009
ATC4	BLK3B	217	3	.165	.004	.367	-.035	-.039
ATC5	BLK5A	500	6	.267	.002	.374	-.009	-.011
ATC6	BLK5B	495	3	.216	-.021	.274	-.023	-.002
ATC7	FAA	536	2	.490	-.009	.540	-.005	.003
ATC(A)1	FSG	200	0	.389	.000	.471	.000	.000
ATC(A)2	BLK3A	221	3	.279	.029	.348	.013	-.016
ATC(A)3	BLK3B	217	3	.165	.004	.367	-.035	-.039
ATC(A)4	BLK5A	205	0	.322	.000	.438	.000	.000
ATC(A)5	BLK5B	204	1	.214	-.007	.276	-.024	-.017
ATC(A)6	FAA	251	2	.508	-.007	.547	-.008	-.001
ATC(B)1	FSG	284	1	.449	.011	.485	.015	.004
ATC(B)2	BLK2	349	0	.374	.000	.421	.000	.000
ATC(B)3	BLK3A	308	5	.195	-.037	.296	-.022	.015
ATC(B)4	BLK5A	295	5	.312	.017	.414	.037	.020
ATC(B)5	BLK5B	291	4	.264	-.016	.336	-.006	.010
ATC(B)6	FAA	285	0	.485	.000	.529	.000	.000

Table G-3

Effect of Dropping High Influence Cases on Multiple Correlations
All Navy Criteria

School	Criterion	Full N	Outliers Dropped	ASVAB R	ASVAB R-Change	ASVAB+ECAT R	ASVAB+ECAT R-Change	Incremental Validity Change
AC1	FSG	72	0	.627	.000	.659	.000	.000
AC2	PERF	76	1	.330	.028	.498	.095	.067
AC3	FAA	76	0	.454	.000	.562	.000	.000
AE1	FSG	278	2	.489	.008	.550	.001	-.007
AE2	SUM2	273	3	.440	-.008	.498	-.015	-.007
AMS1	FSG	244	1	.599	-.012	.604	-.009	.003
AMS2	PERF	244	2	.393	-.005	.437	-.009	-.004
AO1	FSG	234	0	.504	.000	.537	.000	.000
AO2	PRACTL	229	3	.343	.018	.393	.010	-.008
AV1	FSG	544	0	.517	.000	.539	.000	.000
AV2	BSCAV	192	0	.531	.000	.571	.000	.000
AV3	ADVAV	192	0	.358	.000	.404	.000	.000
AV4	PERFORM	352	4	.379	-.028	.417	-.030	-.002
EM1	FSG	797	0	.451	.000	.471	.000	.000
EM2	PHASE1	797	0	.474	.000	.485	.000	.000
EN1	FSG	750	1	.584	.013	.593	.014	.001
ET1	FSG	86	0	.509	.000	.629	.000	.000
ET2	FSG2	86	1	.504	.035	.574	.015	-.020
ET3	PERF	86	2	.482	.044	.585	.077	.033
FC1	FSG	778	0	.499	.000	.536	.000	.000
FC2	RADAR	780	2	.345	-.005	.388	-.009	-.003
GM1	FSG	420	1	.428	.005	.465	.010	.005
GM2	HALF1	420	1	.442	.006	.496	.011	.006
GM3	HALF2	397	2	.458	.003	.479	.007	.004
MM1	FSG	801	0	.402	.000	.438	.000	.000
OS1	FSG	713	2	.565	.008	.588	.009	.001
OS2	WRIT	815	2	.478	.001	.496	.000	-.001
OS3	PERF	815	1	.523	-.001	.566	-.001	.000
RM1	FSG	277	0	.536	.000	.592	.000	.000
RM2	PHASE3	277	0	.420	.000	.467	.000	.000

Appendix H

Uncorrected and Corrected Moments and Reliabilities of the Criteria

Table H-1

Army Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

						Uncorrected			Corrected		
School	Criterion	N	Missing	Skewness	Kurtosis	Mean	Std.Dev.	Reliability	Mean	Std.Dev.	Reliability
11H(A)1	TOALL	554	4	-7.4	65.5	2.980	0.060	0.900	2.975	0.061	0.903
11H(A)2	EVT1TO	556	2	-0.5	0.1	502.128	149.898	0.900	477.324	155.650	0.907
11H(A)3	EVT2TO	555	3	-0.6	0.5	578.679	135.408	0.920	565.440	137.756	0.923
11H(A)4	EVT3TO	550	8	-0.5	1.8	658.964	92.695	0.910	645.535	95.488	0.915
11H(A)5	EVTSUM	546	12	-0.4	0.3	1741.947	317.995	0.960	1691.799	329.836	0.963
11H(A)6	TO_1	542	16	-1.1	3.5	665.579	85.720	0.890	659.065	87.036	0.893
11H(B)1	TOALL	320	1	-5.5	41.7	2.992	0.020	0.880	2.988	0.021	0.888
11H(B)2	EVT1TO	320	1	-0.5	-0.3	501.619	162.490	0.920	477.015	165.521	0.923
11H(B)3	EVT2TO	319	2	-0.9	1.5	582.288	138.703	0.920	555.478	145.053	0.927
11H(B)4	EVT3TO	319	2	-0.7	1.2	661.555	100.532	0.910	650.523	102.277	0.913
11H(B)5	EVTSUM	316	5	-0.5	0.5	1744.715	329.589	0.960	1680.733	342.235	0.963
11H(B)6	TO_1	319	2	-0.6	0.3	533.317	150.441	0.860	534.050	151.833	0.863
11H(B)7	TO_2	320	1	-0.8	1.2	585.066	129.647	0.860	580.519	130.229	0.861
11H(B)8	TO_3	319	2	-0.5	2.9	477.545	56.184	0.830	475.174	56.331	0.831
11H(B)9	ITVTOW	318	3	-0.4	0.3	1596.399	280.551	0.920	1592.245	282.874	0.921
13F1	FSG	821	5	-0.5	-0.1	90.413	4.127	0.720	88.769	4.870	0.799
13F2	MPRAD	821	5	-0.9	0.7	91.546	5.113	0.600	89.643	5.939	0.704
13F3	FIRING	821	5	-0.4	-0.3	87.851	5.731	0.580	85.936	6.396	0.663
19K1	COMM	1158	201	-6.5	52.6	1.965	0.175	.046	1.966	0.175	.
19K2	WEAPON	1325	34	-1.6	3.0	1.771	0.330	.338	1.747	0.332	.
19K3	LANDNAV	1192	167	-2.8	9.6	1.897	0.243	.056	1.880	0.245	.
19K4	LOADER	1313	46	-1.2	0.1	1.864	0.200	.066	1.860	0.200	.
19K5	MAINT	1329	30	-4.4	39.7	1.952	0.133	.093	1.945	0.134	.
19K6	NBC	1313	46	-2.0	4.6	1.902	0.180	.072	1.891	0.181	.
19K7	AVERAGE	1106	253	-1.2	2.7	1.884	0.106	0.366	1.874	0.107	0.381

Table H-2

Air Force Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

						Uncorrected			Corrected		
School	Criterion	N	Missing	Skewness	Kurtosis	Mean	Std.Dev.	Reliability	Mean	Std.Dev.	Reliability
APS1	FSG	446	0	0.1	-0.1	80.838	7.014	0.770	77.734	9.365	0.871
APS2	ZHRS	446	0	0.7	0.7	-0.081	0.849	0.840	0.325	1.017	0.889
APS3	AFPT70	432	14	1.5	3.6	30.072	7.840	0.925	26.365	8.183	0.931
ATC1	FSG	484	148	0.1	-0.5	83.260	5.520	0.745	79.399	6.883	0.836
ATC2	BLK2	349	283	-0.8	-0.4	-0.034	1.804	0.690	-0.930	2.080	0.767
ATC3	BLK3A	529	103	-2.6	7.8	0.021	1.620	0.474	-0.318	1.651	0.493
ATC4	BLK3B	217	415	-6.7	53.9	0.041	1.707	0.790	-0.273	1.766	0.804
ATC5	BLK5A	500	132	-2.5	5.1	-0.018	1.824	0.635	-0.785	1.983	0.691
ATC6	BLK5B	495	137	-1.9	4.5	0.008	1.623	0.599	-0.592	1.723	0.644
ATC7	FAA	536	96	-0.7	0.5	83.215	7.796	.	76.756	10.602	.
ATC(A)1	FSG	200	60	0.0	-0.6	82.520	5.864	0.730	78.729	7.171	0.819
ATC(A)2	BLK3A	221	39	-2.6	5.9	0.038	1.694	0.550	-0.231	1.713	0.560
ATC(A)3	BLK3B	217	43	-6.7	53.9	0.041	1.707	0.790	-0.273	1.766	0.804
ATC(A)4	BLK5A	205	55	-2.4	4.5	-0.012	1.686	0.400	-0.671	1.857	0.505
ATC(A)5	BLK5B	204	56	-2.1	4.3	-0.012	1.637	0.570	-0.376	1.695	0.599
ATC(A)6	FAA	251	9	-0.4	-0.0	79.096	8.057	.	73.389	10.686	.
ATC(B)1	FSG	284	88	0.3	-0.5	83.782	5.212	0.760	79.861	6.673	0.854
ATC(B)2	BLK2	349	23	-0.8	-0.4	-0.034	1.804	0.690	-0.930	2.080	0.767
ATC(B)3	BLK3A	308	64	-2.7	9.8	0.009	1.567	0.420	-0.208	1.589	0.436
ATC(B)4	BLK5A	295	77	-2.6	5.3	-0.022	1.917	0.800	-0.892	2.081	0.830
ATC(B)5	BLK5B	291	81	-1.8	4.8	0.021	1.616	0.620	-0.828	1.794	0.692
ATC(B)6	FAA	285	87	-0.4	-0.3	86.842	5.398	.	82.507	7.147	.

Table H-3

Navy Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

						Uncorrected			Corrected		
School	Criterion	N	Missing	Skewness	Kurtosis	Mean	Std.Dev.	Reliability	Mean	Std.Dev.	Reliability
AC1	FSG	72	4	0.4	-0.7	84.525	4.749	0.900	79.562	7.035	0.954
AC2	PERF	76	0	-0.6	0.1	90.790	4.826	0.590	88.947	5.467	0.680
AC3	FAA	76	0	-0.2	0.6	79.632	6.335	.	76.484	7.584	.
AE1	FSG	278	0	-0.6	2.1	83.307	6.074	0.900	82.024	6.964	0.924
AE2	SUM2	273	5	-1.6	4.3	88.170	7.562	0.804	86.729	8.325	0.838
AMS1	FSG	244	0	0.1	-0.2	83.585	4.028	0.860	80.297	5.741	0.931
AMS2	PERF	244	0	-0.5	0.5	85.100	3.309	0.700	83.486	3.815	0.774
AO1	FSG	234	0	0.0	-0.5	85.897	5.349	0.846	85.017	6.484	0.895
AO2	PRACTL	229	5	-1.7	3.8	93.560	4.637	0.724	93.324	4.959	0.759
AV1	FSG	544	0	0.1	-0.7	90.043	3.791	0.931	85.296	5.444	0.967
AV2	BSCAV	192	352	-0.2	-0.9	84.771	7.861	0.884	72.929	12.228	0.952
AV3	ADVAV	192	352	-0.2	-0.3	88.366	5.031	0.817	83.859	6.428	0.888
AV4	PERFORM	352	192	-2.1	7.2	96.749	2.712	0.579	94.891	3.078	0.673
EM1	FSG	797	0	0.2	-0.7	87.906	4.719	0.920	86.995	5.687	0.945
EM2	PHASE1	797	0	-0.5	-0.0	87.835	6.479	0.835	86.299	7.906	0.889
EN1	FSG	750	0	-0.5	6.6	84.873	5.185	0.878	84.007	6.196	0.915
ET1	FSG	86	0	0.2	-0.7	81.679	5.953	0.825	74.247	9.381	0.930
ET2	FSG2	86	0	-0.3	-0.1	82.909	6.025	0.928	74.693	9.929	0.973
ET3	PERF	86	0	-1.1	1.4	84.928	9.444	0.772	75.570	13.303	0.885
FC1	FSG	778	2	0.3	-0.6	84.965	4.806	0.924	78.597	7.313	0.967
FC2	RADAR	780	0	-0.3	-0.0	82.470	7.161	0.675	76.293	8.992	0.794
GM1	FSG	420	0	0.0	-0.5	85.838	4.896	0.920	84.103	6.394	0.953
GM2	HALF1	420	0	-0.1	-0.6	85.456	5.367	0.870	83.393	7.168	0.927
GM3	HALF2	397	23	-0.7	2.2	87.997	4.841	0.870	86.467	6.140	0.919
MM1	FSG	801	0	0.2	-0.6	82.689	6.353	0.880	81.803	6.896	0.898
OS1	FSG	713	102	-0.4	-0.2	88.739	4.427	0.850	87.346	5.762	0.911
OS2	WRIT	815	0	-0.3	-0.2	88.236	4.608	0.749	87.218	5.627	0.832
OS3	PERF	815	0	-0.6	-0.1	89.656	4.904	0.705	88.309	5.991	0.802
RM1	FSG	277	0	-0.1	-0.8	94.787	2.527	0.800	94.362	3.154	0.872
RM2	PHASE3	277	0	-0.7	-0.0	94.366	3.408	0.600	94.040	3.882	0.692

Appendix I

Test Validities and Incremental Validities for All Criteria

Table I-1

ECAT Incremental Validities for all Army Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{6,N-17}$	ASVAB	Increase	Percent
11H(A)1	TOALL	554	.242	.275	1.807	1.40×10^{-1}	.272	.013	4.7
11H(A)2	EVT1TO	556	.316	.362	3.644	3.59×10^{-3}	.404	.030	7.4 **
11H(A)3	EVT2TO	555	.242	.286	2.549	3.46×10^{-2}	.273	.034	12.6 *
11H(A)4	EVT3TO	550	.294	.329	2.438	4.48×10^{-2}	.365	.019	5.3 *
11H(A)5	EVTSUM	546	.321	.373	4.119	1.53×10^{-3}	.392	.036	9.2 **
11H(A)6	TO_1	542	.210	.269	3.031	1.52×10^{-2}	.240	.046	19.1 *
11H(B)1	TOALL	320	.313	.335	1.629	5.53×10^{-1}	.372	.000	0.1
11H(B)2	EVT1TO	320	.291	.398	8.765	2.62×10^{-4}	.305	.089	29.1 **
11H(B)3	EVT2TO	319	.312	.434	11.171	1.50×10^{-5}	.389	.095	24.5 **
11H(B)4	EVT3TO	319	.234	.292	3.308	1.29×10^{-1}	.243	.029	11.9
11H(B)5	EVTSUM	316	.330	.446	11.216	1.64×10^{-5}	.382	.091	23.7 **
11H(B)6	TO_1	319	.144	.317	8.843	2.47×10^{-4}	.014	.269	1979 **
11H(B)7	TO_2	320	.172	.309	7.313	1.48×10^{-3}	.093	.162	173.6 **
11H(B)8	TO_3	319	.176	.329	8.710	2.90×10^{-4}	.054	.225	418.8 **
11H(B)9	ITVTOW	318	.154	.350	11.203	1.51×10^{-5}	.075	.237	316.3 **
13F1	FSG	821	.544	.597	9.483	9.81×10^{-14}	.790	.024	3.0 **
13F2	MPRAD	821	.513	.590	12.950	$<1.0\times10^{-17}$	.809	.040	4.9 **
13F3	FIRING	821	.444	.466	2.507	2.82×10^{-3}	.730	.007	1.0 **
19K1	COMM	1158	.080	.135	1.208	3.28×10^{-2}	.000	.071	. *
19K2	WEAPON	1325	.187	.205	.738	1.41×10^{-1}	.198	.006	3.2
19K3	LANDNA	1192	.175	.192	.617	2.99×10^{-1}	.190	.005	2.5
19K4	LOADER	1313	.066	.087	.330	6.40×10^{-1}	.000	.000	.
19K5	MAINT	1329	.128	.154	.767	1.23×10^{-1}	.109	.011	10.4
19K6	NBC	1313	.119	.136	.429	4.75×10^{-1}	.128	.001	0.5
19K7	AVERAG	1106	.208	.226	.834	1.70×10^{-1}	.392	.006	1.7

$$\text{Percent Variance} = 100\frac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}.$$

* p < .05. ** p < .01.

Table I-2

ECAT Incremental Validities for all Air Force Criteria

School	Criterion	Sample Size	Uncorrected Multiple R: ASVAB	Uncorrected Multiple R: ASVAB +ECAT	Uncorrected Multiple R: Percent Variance	Uncorrected Multiple R: Probability of $F_{6,N-17}$	Corrected Multiple R: ASVAB	Corrected Multiple R: Increase	Corrected Multiple R: Percent
APS1	FSG	446	.545	.581	6.233	2.17×10^{-4}	.828	.012	1.5 **
APS2	ZHRS	446	.424	.476	6.059	2.94×10^{-4}	.680	.023	3.4 **
APS3	AFPT70	432	.294	.404	9.129	2.28×10^{-6}	.388	.079	20.4 **
ATC1	FSG	484	.403	.445	4.540	1.98×10^{-3}	.727	.020	2.7 **
ATC2	BLK2	349	.374	.410	3.373	8.60×10^{-2}	.660	.009	1.4
ATC3	BLK3A	529	.153	.217	2.481	4.99×10^{-2}	.267	.062	23.1 *
ATC4	BLK3B	217	.165	.341	10.057	3.61×10^{-3}	.000	.368	. **
ATC5	BLK5A	500	.267	.359	6.618	2.45×10^{-5}	.494	.090	18.2 **
ATC6	BLK5B	495	.216	.263	2.422	7.45×10^{-2}	.444	.031	7.0
ATC7	FAA	536	.490	.523	4.600	6.64×10^{-4}	.757	.013	1.7 **
ATC(A)1	FSG	200	.389	.464	8.205	2.37×10^{-2}	.680	.043	6.3 *
ATC(A)2	BLK3A	221	.279	.314	2.339	5.75×10^{-1}	.302	.000	0.1
ATC(A)3	BLK3B	217	.165	.341	10.057	3.61×10^{-3}	.000	.368	. **
ATC(A)4	BLK5A	205	.322	.404	7.127	4.18×10^{-2}	.614	.079	12.9 *
ATC(A)5	BLK5B	204	.214	.254	2.008	7.10×10^{-1}	.276	.013	4.6
ATC(A)6	FAA	251	.508	.543	5.179	6.39×10^{-2}	.744	.011	1.5
ATC(B)1	FSG	284	.449	.480	3.788	1.25×10^{-1}	.758	.009	1.2
ATC(B)2	BLK2	349	.374	.410	3.373	8.60×10^{-2}	.660	.009	1.4
ATC(B)3	BLK3A	308	.195	.284	4.627	3.92×10^{-2}	.208	.142	68.4 *
ATC(B)4	BLK5A	295	.312	.408	8.316	1.04×10^{-3}	.450	.100	22.2 **
ATC(B)5	BLK5B	291	.264	.330	4.376	6.61×10^{-2}	.541	.041	7.6
ATC(B)6	FAA	285	.485	.516	4.160	8.83×10^{-2}	.728	.015	2.1

$$\text{Percent Variance} = 100\frac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}.$$

* p < .05.   ** p < .01.

Table I-3

ECAT Incremental Validities for all Navy Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{6,N-17}$	ASVAB	Increase	Percent
AC1	FSG	72	.627	.649	4.978	8.37×10^{-1}	.839	.000	0
AC2	PERF	76	.330	.460	13.033	2.80×10^{-1}	.381	.149	39.2
AC3	FAA	76	.454	.540	11.968	3.31×10^{-1}	.551	.043	7.8
AE1	FSG	278	.489	.542	7.810	3.04×10^{-3}	.659	.023	3.5 **
AE2	SUM2	273	.440	.487	5.808	2.39×10^{-2}	.608	.022	3.7 *
AMS1	FSG	244	.599	.602	.555	9.73×10^{-1}	.848	.000	0
AMS2	PERF	244	.393	.431	3.892	1.89×10^{-1}	.650	.016	2.4
AO1	FSG	234	.504	.522	2.434	5.10×10^{-1}	.717	.005	0.7
AO2	PRACTL	229	.343	.374	2.652	4.69×10^{-1}	.490	.010	2.1
AV1	FSG	544	.517	.536	2.772	2.49×10^{-2}	.810	.005	0.7 *
AV2	BSCAV	192	.531	.565	5.494	1.49×10^{-1}	.844	.008	0.9
AV3	ADVAV	192	.358	.402	4.003	3.26×10^{-1}	.694	.009	1.3
AV4	PERFOR	352	.379	.409	2.853	1.48×10^{-1}	.673	.016	2.4
EM1	FSG	797	.451	.459	.864	3.47×10^{-1}	.687	.000	0
EM2	PHASE1	797	.474	.482	.950	2.86×10^{-1}	.729	.001	0.1
EN1	FSG	750	.584	.588	.721	5.09×10^{-1}	.763	.000	0
ET1	FSG	86	.509	.603	16.470	9.42×10^{-2}	.805	.043	5.3
ET2	FSG2	86	.504	.566	9.738	3.60×10^{-1}	.813	.027	3.3
ET3	PERF	86	.482	.574	14.533	1.41×10^{-1}	.735	.075	10.2
FC1	FSG	778	.499	.528	4.180	2.28×10^{-5}	.828	.010	1.2 **
FC2	RADAR	780	.345	.381	3.053	7.93×10^{-4}	.733	.016	2.1 **
GM1	FSG	420	.428	.454	2.911	7.10×10^{-2}	.731	.004	0.6
GM2	HALF1	420	.442	.478	4.273	9.48×10^{-3}	.762	.008	1.0 **
GM3	HALF2	397	.458	.467	1.033	6.87×10^{-1}	.734	.000	0
MM1	FSG	801	.402	.425	2.362	5.41×10^{-3}	.557	.012	2.2 **
OS1	FSG	713	.565	.582	2.969	2.33×10^{-3}	.804	.007	0.9 **
OS2	WRIT	815	.478	.489	1.405	8.34×10^{-2}	.756	.003	0.4
OS3	PERF	815	.523	.564	6.510	3.81×10^{-9}	.791	.025	3.1 **
RM1	FSG	277	.536	.587	8.796	1.17×10^{-3}	.775	.022	2.8 **
RM2	PHASE3	277	.420	.464	4.907	5.08×10^{-2}	.702	.017	2.4

$$\text{Percent Variance} = 100\frac{\Delta R^2}{1-R^2_{ASVAB+ECAT}}.$$

* p < .05. ** p < .01.

Table I-4

Incremental Validities from Adding one ECAT test to the ASVAB All Significant Criteria from Full Model

School	Criterion	Mental Counters	Sequential Memory	Integrating Details	Assembling Objects
11H(A)2	EVT1TO	.012*	.004	.008*	.015**
11H(A)3	EVT2TO	.009	.004	.001	.026**
11H(A)4	EVT3TO	.006	.009	.000	.025**
11H(A)5	EVTSUM	.013*	.008	.004	.027**
11H(A)6	TO_1	.000	.000	.000	.000
11H(B)2	EVT1TO	.000	.037**	.018*	.007
11H(B)3	EVT2TO	.020*	.036**	.026**	.008
11H(B)5	EVTSUM	.008	.024*	.016*	.003
11H(B)6	TO_1	.084	.116	.000	.078*
11H(B)7	TO_2	.000	.000	.034*	.021
11H(B)8	TO_3	.000	.000	.009	.053*
11H(B)9	ITVTOW	.000	.000	.006	.056*
13F1	FSG	.010**	.009**	.012**	.012**
13F2	MPRAD	.019**	.011**	.023**	.021**
13F3	FIRING	.002*	.007**	.002*	.002*
19K1	COMM	.000	.000	.000	.000
APS1	FSG	.002	.006**	.003*	.000
APS2	ZHRS	.003*	.023**	.000	.000
APS3	AFPT70	.018**	.034**	.025**	.010*
ATC1	FSG	.015**	.004	.001	.005*
ATC3	BLK3A	.022	.038*	.005	.000
ATC4	BLK3B	.165	.210**	.000	.000
ATC5	BLK5A	.078**	.019	.018**	.027**
ATC7	FAA	.018**	.001	.001*	.004*
ATC(A)1	FSG	.037**	.015*	.002	.002
ATC(A)3	BLK3B	.165	.210**	.000	.000
ATC(A)4	BLK5A	.111**	.006	.026*	.015
ATC(B)3	BLK3A	.058	.127*	.006	.000
ATC(B)4	BLK5A	.060*	.032	.014	.040*
AC2	PERF	.048	.135*	.045	.126*
AE1	FSG	.010**	.020**	.019**	.009*
AE2	SUM2	.008*	.018**	.005	.004
AV1	FSG	.007**	.002*	.002*	.002*
FC1	FSG	.000	.000	.001	.003**
FC2	RADAR	.000	.005**	.000	.001
GM2	HALF1	.007**	.000	.001	.001
GM3	HALF2	.002	.000	.000	.002
OS1	FSG	.007**	.003*	.002*	.002*
OS3	PERF	.017**	.011**	.006**	.010**
RM1	FSG	.004	.002	.004	.000

* $p < .05$. ** $p < .01$.

Table I-4 (continued)

School	Criterion	One-hand Tracking	Two-hand Tracking	Target Identification	Spatial Orientaion
11H(A)2	EVT1TO	.013*	.021**	.006	.017**
11H(A)3	EVT2TO	.020*	.028**	.024*	.004
11H(A)4	EVT3TO	.014*	.021**	.003	.003
11H(A)5	EVTSUM	.019**	.029**	.011*	.010*
11H(A)6	TO_1	.036**	.044**	.000	.008
11H(B)2	EVT1TO	.057**	.081**	.026*	.038**
11H(B)3	EVT2TO	.059**	.071**	.021*	.018*
11H(B)5	EVTSUM	.059**	.078**	.021*	.022**
11H(B)6	TO_1	.132*	.152**	.000	.027
11H(B)7	TO_2	.138**	.160**	.000	.014
11H(B)8	TO_3	.201**	.182**	.000	.108**
11H(B)9	ITVTOW	.159**	.172**	.000	.047*
13F1	FSG	.005**	.003**	.003*	.010**
13F2	MPRAD	.003**	.003**	.004**	.014**
13F3	FIRING	.006**	.002*	.002	.002*
19K1	COMM	.000	.000	.030*	.000
APS1	FSG	.000	.000	.000	.002*
APS2	ZHRS	.000	.000	.004*	.000
APS3	AFPT70	.006	.028**	.000	.004
ATC1	FSG	.006*	.003	.008**	.010**
ATC3	BLK3A	.030*	.059**	.000	.000
ATC4	BLK3B	.000	.074	.000	.091
ATC5	BLK5A	.047**	.031**	.012	.023**
ATC7	FAA	.001	.003*	.000	.007**
ATC(A)1	FSG	.021*	.014*	.016*	.001
ATC(A)3	BLK3B	.000	.074	.000	.091
ATC(A)4	BLK5A	.030	.015	.005	.000
ATC(B)3	BLK3A	.089*	.076*	.008	.029
ATC(B)4	BLK5A	.049**	.034**	.023*	.044**
AC2	PERF	.063	.000	.000	.033
AE1	FSG	.004*	.000	.004	.004*
AE2	SUM2	.000	.000	.009*	.000
AV1	FSG	.000	.002	.000	.001
FC1	FSG	.000	.001*	.001*	.000
FC2	RADAR	.002	.004*	.000	.000
GM2	HALF1	.001	.001	.001	.005**
GM3	HALF2	.000	.000	.000	.001
OS1	FSG	.000	.001	.000	.003*
OS3	PERF	.003*	.006**	.000	.011**
RM1	FSG	.002	.000	.011**	.002

* p < .05. ** p < .01.

Table I-4 (continued)

School	Criterion	Memory Composite	Spatial Composite	Tracking Composite	Figural Reasoning
11H(A)2	EVT1TO	.011*	.016**	.020**	.000
11H(A)3	EVT2TO	.011	.017*	.028**	.002
11H(A)4	EVT3TO	.011*	.012*	.021**	.000
11H(A)5	EVTSUM	.015*	.020**	.028**	.001
11H(A)6	TO_1	.000	.000	.047**	.007
11H(B)2	EVT1TO	.022*	.019*	.080**	.000
11H(B)3	EVT2TO	.039**	.024*	.076**	.000
11H(B)5	EVTSUM	.023*	.013	.080**	.000
11H(B)6	TO_1	.126*	.035*	.156**	.000
11H(B)7	TO_2	.000	.043*	.168**	.000
11H(B)8	TO_3	.000	.050*	.213**	.000
11H(B)9	ITVTOW	.004	.047**	.185**	.000
13F1	FSG	.013**	.017**	.005**	.010**
13F2	MPRAD	.021**	.032**	.004**	.016**
13F3	FIRING	.006**	.003**	.005**	.003**
19K1	COMM	.000	.000	.000	.000
APS1	FSG	.006**	.002*	.000	.010**
APS2	ZHRS	.016**	.000	.000	.004*
APS3	AFPT70	.036**	.024**	.018**	.014**
ATC1	FSG	.013**	.004*	.005*	.000
ATC3	BLK3A	.043*	.000	.051**	.015
ATC4	BLK3B	.229**	.000	.000	.294**
ATC5	BLK5A	.062**	.032**	.045**	.041**
ATC7	FAA	.011**	.004**	.002	.004*
ATC(A)1	FSG	.036**	.004	.021*	.010
ATC(A)3	BLK3B	.229**	.000	.000	.294**
ATC(A)4	BLK5A	.066**	.031**	.027	.060**
ATC(B)3	BLK3A	.125*	.000	.097*	.019
ATC(B)4	BLK5A	.063*	.038*	.049**	.036
AC2	PERF	.128	.123	.025	.070
AE1	FSG	.021**	.020**	.003*	.009*
AE2	SUM2	.019**	.007	.000	.003
AV1	FSG	.007**	.003*	.001	.001
FC1	FSG	.000	.003**	.000	.004**
FC2	RADAR	.003*	.000	.004*	.003
GM2	HALF1	.001	.001	.001*	.004**
GM3	HALF2	.000	.000	.000	.001
OS1	FSG	.007**	.003**	.000	.004**
OS3	PERF	.019**	.012**	.005**	.007**
RM1	FSG	.005	.002	.002	.000

* $p < .05$. ** $p < .01$.

Table I-5

Uncorrected Simple Validities for all Army Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
11H(A)1	TOALL	554	09	16	05	14	07	09	13	16	12	13	22	12	12	12	-04	-04	15	11	01	19	14	-05
11H(A)2	EVT1TO	556	17	15	18	17	01	06	21	19	25	19	18	14	20	23	-17	-21	14	24	-12	18	24	-21
11H(A)3	EVT2TO	555	08	11	11	14	05	06	12	15	15	17	14	12	12	20	-14	-17	12	14	-13	15	18	-17
11H(A)4	EVT3TO	550	18	15	20	22	04	01	15	18	23	18	15	15	14	23	-16	-20	15	18	-10	17	21	-19
11H(A)5	EVTSUM	546	17	15	19	20	03	05	20	20	24	22	19	15	18	26	-18	-23	15	22	-14	19	25	-22
11H(A)6	TO_1	542	13	09	12	08	12	11	05	14	12	04	06	09	10	07	-16	-18	14	14	-08	09	10	-18
11H(B)1	TOALL	320	11	18	23	22	09	06	08	03	15	11	07	13	20	03	-09	-10	20	08	-06	12	13	-10
11H(B)2	EVT1TO	320	20	12	19	16	11	08	09	16	23	21	13	22	23	18	-28	-30	18	27	-20	20	23	-31
11H(B)3	EVT2TO	319	20	17	22	21	20	15	07	14	19	19	18	25	25	17	-29	-31	16	24	-21	24	23	-32
11H(B)4	EVT3TO	319	16	08	07	08	10	04	10	11	17	14	11	04	09	04	-14	-18	02	13	-11	08	07	-17
11H(B)5	EVTSUM	316	24	16	21	19	18	12	11	17	25	23	17	23	25	18	-31	-34	16	28	-22	23	23	-35
11H(B)6	TO_1	319	04	-03	00	-02	-06	-04	00	05	06	03	-04	-08	07	14	-14	-17	01	09	02	-07	12	-17
11H(B)7	TO_2	320	05	-08	00	-01	-09	-07	06	-04	06	01	01	00	10	09	-21	-23	04	07	-01	01	11	-23
11H(B)8	TO_3	319	04	-01	07	-02	09	06	05	05	05	06	02	07	10	13	-25	-23	07	17	-03	05	13	-25
11H(B)9	ITVTOW	318	05	-06	01	-03	-06	-04	03	02	07	03	-01	-03	10	15	-23	-24	04	12	01	-02	14	-25
13F1	FSG	821	32	41	32	34	19	21	29	35	32	30	33	33	39	38	-27	-26	37	38	-20	38	45	-28
13F2	MPRAD	821	32	39	31	30	19	16	27	34	34	30	36	33	43	41	-24	-25	39	39	-20	39	48	-26
13F3	FIRING	821	26	34	27	29	14	18	23	29	22	23	21	26	25	25	-23	-19	26	25	-15	27	29	-22
19K1	COMM	1158	01	00	01	00	03	01	-04	-01	01	01	00	-02	-02	-04	00	02	04	-02	-06	-01	-03	01
19K2	WEAPON	1325	14	11	06	07	06	09	06	15	08	09	08	10	10	09	-08	-05	04	05	-09	10	11	-07
19K3	LANDNAV	1192	10	12	03	05	11	04	04	13	10	07	10	10	07	09	-09	-08	07	06	-02	11	09	-10
19K4	LOADER	1313	04	00	04	02	01	01	03	00	05	03	04	01	02	01	-02	-03	01	04	02	03	01	-03
19K5	MAINT	1329	07	06	02	07	00	05	03	08	04	05	02	06	04	05	-04	-02	-02	06	-05	05	05	-03
19K6	NBC	1313	07	06	05	05	08	08	03	08	05	04	04	03	02	05	-07	-07	03	01	-06	04	04	-07
19K7	AVERAGE	1106	14	12	07	10	12	11	07	15	10	07	12	11	12	12	-10	-08	05	08	-08	13	14	-10

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table I-6

Uncorrected Simple Validities for all Air Force Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
APS1	FSG	446	33	44	27	26	09	07	21	37	28	19	25	28	28	20	-05	-09	33	26	-06	30	27	-08
APS2	ZHRS	446	-13	-32	-20	-15	-15	-16	-08	-29	-07	-04	-21	-29	-12	-07	02	00	-20	-11	10	-29	-11	01
APS3	AFPT70	432	-05	10	13	04	12	17	-08	10	-05	-12	17	21	13	08	10	16	15	09	04	22	12	14
ATC1	FSG	484	21	27	27	16	03	06	22	25	29	26	23	17	22	26	-20	-20	18	27	-17	22	27	-21
ATC2	BLK2	349	22	28	18	11	-03	00	23	23	29	21	15	12	21	15	-23	-22	17	28	-13	15	20	-24
ATC3	BLK3A	529	04	06	07	03	-01	04	03	13	10	03	10	12	09	06	-11	-15	10	05	-02	13	09	-13
ATC4	BLK3B	217	-11	-01	-01	-07	-01	01	-01	-02	03	-02	13	17	-02	01	04	-07	18	11	-01	17	-01	-02
ATC5	BLK5A	500	09	23	00	01	07	01	02	14	15	06	27	16	21	21	-23	-19	20	20	-10	25	24	-23
ATC6	BLK5B	495	03	10	12	00	10	12	01	14	05	01	16	11	09	04	-10	-08	08	11	-05	16	07	-10
ATC7	FAA	536	33	33	33	21	04	07	26	33	32	26	30	16	28	29	-15	-22	26	31	-09	26	33	-20
ATC(A)1	FSG	200	18	26	19	13	10	06	16	25	26	26	29	23	24	27	-27	-27	24	22	-19	30	29	-29
ATC(A)2	BLK3A	221	04	03	10	11	00	08	-05	12	16	-06	07	07	09	10	-04	-12	13	-02	05	08	11	-08
ATC(A)3	BLK3B	217	-11	-01	-01	-07	-01	01	-01	-02	03	-02	13	17	-02	01	04	-07	18	11	-01	17	-01	-02
ATC(A)4	BLK5A	205	05	22	-03	05	-01	04	04	01	20	07	30	10	24	22	-19	-17	20	14	-04	23	26	-19
ATC(A)5	BLK5B	204	-07	04	05	-03	11	11	-03	11	03	-04	13	04	08	05	-09	-05	13	06	-02	10	07	-07
ATC(A)6	FAA	251	34	39	27	19	-01	06	27	33	37	31	29	22	32	33	-23	-29	32	27	-13	29	37	-28
ATC(B)1	FSG	284	24	27	30	19	-06	05	26	24	32	26	14	12	19	23	-16	-15	12	30	-15	15	24	-17
ATC(B)2	BLK2	349	22	28	18	11	-03	00	23	23	29	21	15	12	21	15	-23	-22	17	28	-13	15	20	-24
ATC(B)3	BLK3A	308	04	09	06	-03	-02	01	10	13	05	10	13	17	09	02	-16	-16	08	12	-07	17	07	-17
ATC(B)4	BLK5A	295	12	23	02	-02	14	-01	02	22	11	06	25	20	19	20	-25	-21	20	24	-13	26	23	-25
ATC(B)5	BLK5B	291	10	15	17	01	10	12	04	16	07	04	19	17	09	03	-11	-11	04	15	-07	21	07	-12
ATC(B)6	FAA	285	35	24	32	25	-06	-02	28	30	26	24	26	11	17	16	-20	-22	15	23	-08	21	19	-23

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table I-7
Uncorrected Simple Validities for all Navy Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
AC1	FSG	72	37	42	20	34	12	19	33	43	24	34	34	26	24	23	-11	-20	31	25	-16	35	27	-17
AC2	PERF	76	04	09	-11	08	14	19	-02	01	-05	-09	12	29	08	23	-07	-04	16	17	03	24	18	-06
AC3	FAA	76	21	16	14	38	10	06	29	19	18	29	21	02	17	19	00	-04	22	21	-18	13	20	-02
AE1	FSG	278	38	33	32	31	08	11	36	23	26	29	28	33	36	27	-23	-20	33	28	-20	35	37	-23
AE2	SUM2	273	35	32	18	17	02	07	28	16	26	22	25	31	25	25	-13	-08	25	19	-22	31	30	-12
AMS1	FSG	244	40	29	39	21	26	28	18	38	27	28	08	13	19	23	-08	-06	16	12	-05	12	25	-07
AMS2	PERF	244	14	17	14	-02	24	25	10	17	15	17	10	14	19	25	-09	-08	12	06	-12	14	26	-09
AO1	FSG	234	22	31	20	20	25	27	18	40	22	19	20	09	22	24	-15	-07	19	21	-14	17	26	-12
AO2	PRACTL	229	04	13	09	06	25	26	06	22	07	10	16	13	18	15	-12	-04	16	13	-09	17	18	-08
AV1	FSG	544	11	32	10	16	13	16	15	39	26	19	30	22	27	25	-12	-17	25	25	-05	30	30	-16
AV2	BSCAV	192	20	34	16	18	09	01	07	41	12	15	30	23	33	26	-11	-14	24	25	-06	30	34	-13
AV3	ADVAV	192	14	18	14	16	14	09	02	27	00	09	11	10	20	14	-13	-11	05	05	-11	12	19	-12
AV4	PERFORM	352	00	16	-02	06	01	04	19	20	24	20	18	14	17	19	-18	-16	17	18	02	18	20	-18
EM1	FSG	797	20	33	19	18	10	17	21	26	26	28	23	15	21	16	-10	-11	22	21	-01	22	21	-12
EM2	PHASE1	797	18	35	18	17	07	15	17	30	26	29	22	15	19	19	-07	-11	25	21	-01	21	22	-10
EN1	FSG	750	41	42	35	31	09	18	36	31	43	41	26	20	33	28	-14	-20	31	31	-16	26	34	-18
ET1	FSG	86	27	20	08	13	06	11	26	21	15	21	23	18	29	30	-27	-35	20	25	-03	26	35	-33
ET2	FSG2	86	16	33	09	16	25	24	10	30	06	07	22	25	23	28	-19	-21	22	16	-03	29	31	-21
ET3	PERF	86	-13	30	03	-01	27	26	-03	32	-11	-02	15	20	09	09	-20	-17	09	19	-02	22	11	-20
FC1	FSG	778	20	33	17	23	15	19	17	24	26	22	13	07	21	22	-08	-17	22	20	02	12	25	-14
FC2	RADAR	780	16	17	15	17	10	13	21	06	20	18	04	-05	08	13	-09	-14	12	12	00	-01	12	-13
GM1	FSG	420	14	28	25	16	08	13	21	18	21	12	23	14	19	19	-18	-20	19	24	-02	21	22	-21
GM2	HALF1	420	12	28	21	15	13	16	15	25	25	11	28	15	22	23	-19	-22	24	29	-04	25	25	-22
GM3	HALF2	397	21	22	25	18	06	14	34	10	21	15	16	09	14	22	-13	-15	15	22	-08	14	20	-15
MM1	FSG	801	29	27	20	22	10	16	26	19	28	27	17	13	24	28	-16	-11	24	17	-12	17	29	-15
OS1	FSG	713	29	46	22	18	14	14	25	39	38	25	39	28	36	32	-17	-24	37	34	-14	39	38	-22
OS2	WRIT	815	29	38	25	19	09	03	23	34	33	22	30	23	26	25	-12	-20	29	28	-10	31	29	-17
OS3	PERF	815	23	41	13	16	13	14	25	34	37	21	39	31	36	35	-22	-27	36	34	-17	41	40	-26
RM1	FSG	277	37	43	36	27	09	13	18	33	28	27	25	25	31	21	-07	-09	27	27	01	28	30	-08
RM2.	PHASE3	277	25	33	24	23	00	05	12	23	27	24	21	19	24	19	-08	-11	19	26	00	23	25	-10

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table I-8

Range-Corrected Simple Validities for all Army Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
11H(A)1	TOALL	554	16	21	12	20	10	13	17	20	18	17	24	15	18	17	-07	-09	19	16	-02	22	19	-08
11H(A)2	EVT1TO	556	27	24	27	25	06	11	32	25	34	28	25	21	29	31	-23	-28	24	32	-19	25	33	-27
11H(A)3	EVT2TO	555	16	17	17	20	08	08	20	19	22	22	18	16	19	24	-19	-22	18	20	-19	19	24	-22
11H(A)4	EVT3TO	550	26	24	28	29	09	06	24	25	30	25	21	22	23	30	-21	-25	23	25	-16	24	29	-25
11H(A)5	EVTSUM	546	26	24	28	28	08	09	31	26	33	29	25	22	27	33	-25	-30	25	30	-21	26	33	-29
11H(A)6	TO_1	542	18	14	17	13	17	15	13	18	18	10	11	13	15	12	-21	-23	18	18	-12	13	15	-24
11H(B)1	TOALL	320	20	27	31	32	21	15	18	15	24	19	19	20	26	13	-13	-17	26	15	-09	21	21	-16
11H(B)2	EVT1TO	320	26	21	23	21	17	11	21	21	30	26	19	26	28	25	-30	-35	22	31	-24	25	29	-35
11H(B)3	EVT2TO	319	29	30	32	31	30	23	20	24	28	27	30	33	32	27	-34	-37	23	30	-25	35	33	-38
11H(B)4	EVT3TO	319	20	16	12	13	16	08	17	16	23	19	15	08	16	11	-20	-23	07	16	-14	12	14	-23
11H(B)5	EVTSUM	316	31	28	29	28	26	18	24	26	34	30	27	29	32	27	-35	-40	23	33	-26	31	33	-40
11H(B)6	TO_1	319	03	-04	-03	-04	-10	-08	02	02	06	03	-10	-12	03	10	-14	-15	-01	07	03	-12	07	-15
11H(B)7	TO_2	320	05	-07	-02	-03	-10	-08	08	-05	08	03	-02	-02	08	08	-20	-22	03	07	-01	-02	09	-22
11H(B)8	TO_3	319	07	04	08	01	09	05	10	07	09	08	03	07	10	13	-26	-24	08	17	-05	06	13	-26
11H(B)9	ITVTOW	318	04	-06	-02	-05	-09	-08	06	00	08	03	-06	-07	06	11	-21	-22	02	10	01	-07	10	-23
13F1	FSG	821	52	61	52	54	38	42	41	55	55	45	49	47	54	51	-33	-36	53	51	-30	53	58	-37
13F2	MPRAD	821	51	59	50	50	37	37	40	54	55	44	51	46	56	53	-31	-35	54	52	-30	54	60	-35
13F3	FIRING	821	44	52	44	46	31	36	34	47	43	37	37	39	40	39	-29	-29	42	40	-24	42	43	-31
19K1	COMM	1158	02	01	02	01	03	01	-03	00	01	01	00	-01	-02	-03	01	03	03	-02	-06	-01	-03	02
19K2	WEAPON	1325	17	15	11	12	11	13	11	17	12	13	11	12	12	12	-10	-08	09	09	-11	13	13	-10
19K3	LANDNAV	1192	13	15	07	09	14	07	09	16	15	10	13	12	10	13	-13	-12	10	10	-05	14	13	-13
19K4	LOADER	1313	05	03	05	04	03	03	04	02	06	04	05	03	03	02	-03	-04	02	05	01	04	03	-03
19K5	MAINT	1329	09	09	05	09	03	07	06	10	06	07	05	07	05	07	-05	-04	01	08	-05	07	07	-05
19K6	NBC	1313	11	10	09	09	12	12	06	11	09	07	07	06	05	08	-09	-09	06	05	-08	07	07	-09
19K7	AVERAGE	1106	19	19	14	16	18	17	12	20	17	13	16	15	16	17	-13	-13	11	14	-11	17	18	-14

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table I-9

Range-Corrected Simple Validities for all Air Force Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
APS1	FSG	446	62	70	61	60	41	38	40	64	55	48	48	50	53	47	-24	-28	59	50	-24	54	55	-28
APS2	ZHRS	446	-43	-58	-49	-46	-42	-40	-23	-55	-35	-30	-42	-49	-37	-32	19	19	-45	-34	25	-51	-38	20
APS3	AFPT70	432	14	31	26	23	28	29	03	28	14	06	30	34	27	22	-02	03	28	21	-05	35	27	01
ATC1	FSG	484	52	58	58	53	31	30	39	49	52	46	46	41	44	45	-32	-33	45	49	-31	48	49	-35
ATC2	BLK2	349	47	53	47	43	18	20	39	39	48	38	35	33	41	33	-31	-30	39	44	-26	38	41	-33
ATC3	BLK3A	529	13	16	16	15	10	13	07	20	16	07	19	21	17	13	-16	-20	19	13	-07	22	16	-19
ATC4	BLK3B	217	01	14	08	05	08	09	03	07	11	01	22	25	05	06	-05	-15	28	16	-08	26	06	-11
ATC5	BLK5A	500	26	41	20	23	25	20	14	31	30	18	44	33	34	34	-31	-29	39	33	-21	43	37	-32
ATC6	BLK5B	495	21	30	28	21	26	26	10	29	20	12	32	27	22	17	-20	-20	25	24	-15	32	21	-21
ATC7	FAA	536	62	66	66	60	35	34	44	56	56	48	53	43	50	49	-30	-37	54	53	-27	53	54	-36
ATC(A)1	FSG	200	43	58	48	48	38	31	33	50	47	43	52	45	44	41	-37	-37	49	42	-33	54	47	-39
ATC(A)2	BLK3A	221	08	08	08	12	09	14	-04	16	16	-05	12	13	11	11	-10	-20	13	05	00	14	12	-16
ATC(A)3	BLK3B	217	01	14	08	05	08	09	03	07	11	01	22	25	05	06	-05	-15	28	16	-08	26	06	-11
ATC(A)4	BLK5A	205	22	42	19	26	20	20	19	22	35	20	46	30	35	32	-28	-27	40	28	-20	42	37	-30
ATC(A)5	BLK5B	204	06	20	14	11	23	22	04	21	12	02	25	16	15	11	-19	-16	23	15	-10	23	14	-19
ATC(A)6	FAA	251	61	68	62	58	34	31	44	56	59	50	52	45	51	50	-33	-38	57	51	-29	54	56	-38
ATC(B)1	FSG	284	56	59	63	56	23	27	45	46	55	48	39	38	44	43	-29	-30	41	50	-30	43	48	-32
ATC(B)2	BLK2	349	47	53	47	43	18	20	39	39	48	38	35	33	41	33	-31	-30	39	44	-26	38	41	-33
ATC(B)3	BLK3A	308	10	14	12	06	03	07	12	17	10	13	18	23	15	09	-19	-18	16	17	-11	23	14	-20
ATC(B)4	BLK5A	295	27	39	20	19	30	21	10	38	25	17	43	37	33	36	-32	-29	39	37	-25	44	38	-33
ATC(B)5	BLK5B	291	33	40	40	30	27	30	17	36	27	19	38	36	29	23	-22	-24	28	33	-20	41	29	-25
ATC(B)6	FAA	285	61	60	64	61	25	27	45	52	53	45	50	41	45	42	-33	-37	48	47	-26	51	48	-37

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Table I-10
Range-Corrected Simple Validities for all Navy Criteria

School	Criterion	N	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI	CT	SM	ID	AO	T1	T2	FR	SO	TI	Memory	Spatial	Tracking
AC1	FSG	72	61	71	51	56	45	49	34	76	49	50	53	48	47	52	-22	-27	57	47	-24	56	55	-27
AC2	PERF	76	17	28	06	19	24	33	-05	31	09	05	35	43	29	36	-27	-14	34	26	-02	43	36	-22
AC3	FAA	76	47	42	41	53	30	30	32	46	38	45	30	16	31	36	-02	-04	39	38	-26	25	37	-03
AE1	FSG	278	54	55	51	48	31	28	45	47	50	47	43	45	52	46	-31	-32	49	45	-29	49	54	-34
AE2	SUM2	273	50	50	36	35	24	23	36	40	46	39	39	40	43	40	-22	-20	41	38	-30	44	46	-22
AMS1	FSG	244	69	65	65	56	40	42	55	60	67	60	43	44	53	51	-32	-36	50	49	-31	48	58	-36
AMS2	PERF	244	42	44	36	26	34	34	39	36	46	43	33	35	43	44	-27	-29	35	34	-30	38	48	-30
AO1	FSG	234	53	57	49	49	40	39	34	61	47	46	42	34	46	45	-36	-31	47	43	-31	42	50	-36
AO2	PRACTL	229	26	31	31	29	35	35	14	38	24	25	30	29	31	29	-25	-18	34	27	-21	33	33	-23
AV1	FSG	544	58	70	54	53	38	36	42	69	60	56	54	48	55	52	-31	-37	54	52	-26	56	59	-36
AV2	BSCAV	192	67	72	62	58	39	30	42	71	57	59	54	49	59	53	-29	-37	57	54	-25	57	62	-35
AV3	ADVAV	192	54	53	54	53	38	31	30	56	41	45	36	36	45	40	-29	-31	36	34	-27	40	47	-32
AV4	PERFORM	352	32	42	26	28	14	13	39	39	47	44	35	29	38	40	-32	-30	36	37	-14	36	43	-33
EM1	FSG	797	51	60	47	45	34	33	35	57	50	46	43	36	46	39	-26	-27	46	43	-18	43	47	-28
EM2	PHASE1	797	51	62	46	45	33	32	33	60	50	47	43	37	46	42	-24	-27	49	43	-19	44	48	-27
EN1	FSG	750	59	60	55	51	31	29	53	53	60	57	41	34	49	45	-29	-34	47	47	-28	42	52	-34
ET1	FSG	86	67	69	53	50	35	39	48	60	54	61	55	53	64	59	-38	-52	58	57	-32	60	68	-48
ET2	FSG2	86	64	75	56	56	51	48	40	66	55	54	57	58	62	58	-39	-47	63	57	-34	63	66	-46
ET3	PERF	86	40	67	44	36	44	44	28	57	34	39	47	44	47	39	-46	-43	48	52	-37	50	48	-48
FC1	FSG	778	65	71	61	60	40	38	46	64	64	61	44	40	55	54	-29	-38	58	52	-23	47	60	-36
FC2	RADAR	780	54	53	52	50	30	29	46	43	53	52	31	24	40	41	-29	-35	45	41	-21	30	45	-34
GM1	FSG	420	55	64	58	51	34	32	45	56	54	50	46	37	47	44	-31	-34	50	48	-20	46	51	-35
GM2	HALF1	420	56	66	56	51	38	35	41	61	57	50	50	39	50	47	-31	-34	54	52	-20	49	54	-35
GM3	HALF2	397	57	60	56	50	31	31	52	50	52	50	41	33	43	45	-27	-30	47	46	-24	41	48	-30
MM1	FSG	801	44	42	36	38	24	25	38	39	43	41	30	27	38	39	-25	-23	40	31	-20	31	42	-26
OS1	FSG	713	56	67	55	55	46	49	34	66	55	45	53	48	52	49	-27	-34	54	50	-26	56	56	-33
OS2	WRIT	815	53	60	53	51	39	38	33	60	51	42	46	42	43	43	-24	-32	48	45	-21	49	47	-30
OS3	PERF	815	48	61	44	49	43	45	34	60	52	41	54	49	51	51	-32	-37	52	51	-26	57	56	-37
RM1	FSG	277	59	64	59	55	41	45	32	56	51	46	47	45	50	43	-19	-25	46	47	-12	51	51	-23
RM2	PHASE3	277	46	53	45	46	26	32	26	44	47	41	39	35	42	39	-18	-24	35	42	-11	41	44	-22

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
AO = Assembling Objects Proportion Correct
FR = Figural Reasoning Proportion Correct
SM = Sequential Memory Proportion Correct
T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
SO = Spatial Orientation Proportion Correct
ID = Integrating Details Proportion Correct
T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
TI = Target Identification Mean Clipped Decision RTs

Appendix J

Factor Validities and Incremental Validities for All Criteria

Table J-1

ECAT Factor Incremental Validities for all Army Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{3,N-8}$	ASVAB	Increase	Percent
11H(A)1	TOALL	554	.204	.222	0.792	2.299×10^{-1}	.247	.006	2.3
11H(A)2	EVT1TO	556	.276	.327	3.427	3.499×10^{-4}	.383	.034	8.8 **
11H(A)3	EVT2TO	555	.190	.235	2.054	1.104×10^{-2}	.247	.033	13.4 *
11H(A)4	EVT3TO	550	.260	.300	2.466	4.192×10^{-3}	.349	.026	7.3 **
11H(A)5	EVTSUM	546	.279	.334	3.830	1.513×10^{-4}	.370	.038	10.4 **
11H(A)6	TO_1	542	.169	.221	2.137	1.019×10^{-2}	.219	.050	22.8 *
11H(B)1	TOALL	320	.244	.266	1.199	2.929×10^{-1}	.344	.000	0.0
11H(B)2	EVT1TO	320	.244	.366	8.614	1.039×10^{-5}	.304	.089	29.3 **
11H(B)3	EVT2TO	319	.292	.407	9.656	2.575×10^{-6}	.401	.082	20.5 **
11H(B)4	EVT3TO	319	.191	.248	2.686	4.099×10^{-2}	.238	.036	15.2 *
11H(B)5	EVTSUM	316	.292	.412	10.186	1.432×10^{-6}	.381	.084	21.9 **
11H(B)6	TO_1	319	.102	.281	7.457	5.377×10^{-5}	.099	.194	196.5 **
11H(B)7	TO_2	320	.119	.278	6.830	1.247×10^{-4}	.106	.165	156.2 **
11H(B)8	TO_3	319	.099	.266	6.536	1.938×10^{-4}	.052	.196	376.2 **
11H(B)9	ITVTOW	318	.087	.303	9.303	4.363×10^{-6}	.088	.214	243.6 **
13F1	FSG	821	.523	.583	10.158	5.551×10^{-17}	.778	.029	3.7 **
13F2	MPRAD	821	.503	.586	13.706	$< 10^{-17}$	.806	.045	5.6 **
13F3	FIRING	821	.419	.444	2.771	5.830×10^{-5}	.713	.012	1.7 **
19K1	COMM	1158	.037	.044	0.056	8.858×10^{-1}	.000	.000	.
19K2	WEAPON	1325	.163	.165	0.094	7.434×10^{-1}	.188	.000	0.0
19K3	LANDNAV	1192	.162	.171	0.319	2.870×10^{-1}	.188	.005	2.5
19K4	LOADER	1313	.048	.050	0.020	9.664×10^{-1}	.029	.000	0.0
19K5	MAINT	1329	.087	.090	0.055	8.657×10^{-1}	.089	.000	0.0
19K6	NBC	1313	.111	.124	0.330	2.305×10^{-1}	.137	.005	4.0
19K7	AVERAG	1106	.193	.196	0.159	6.258×10^{-1}	.390	.000	0.0

* $p < .05$. ** $p < .01$.

Table J-2

ECAT Factor Incremental Validities for all Air Force Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{3,N-8}$	ASVAB	Increase	Percent
APS1	FSG	446	.526	.559	5.326	4.546×10^{-5}	.823	.013	1.6 **
APS2	ZHRS	446	.391	.449	6.189	8.122×10^{-6}	.669	.030	4.5 **
APS3	AFPT70	432	.265	.391	9.807	1.225×10^{-8}	.373	.102	27.3 **
ATC1	FSG	484	.387	.417	2.848	3.884×10^{-3}	.722	.015	2.0 **
ATC2	BLK2	349	.352	.373	1.739	1.172×10^{-1}	.646	.009	1.3
ATC3	BLK3A	529	.125	.189	2.086	1.305×10^{-2}	.266	.077	28.7 *
ATC4	BLK3B	217	.046	.210	4.401	2.899×10^{-2}	.000	.252	. *
ATC5	BLK5A	500	.215	.327	6.809	4.224×10^{-7}	.460	.103	22.4 **
ATC6	BLK5B	495	.182	.217	1.444	7.225×10^{-2}	.430	.028	6.5
ATC7	FAA	536	.480	.503	3.065	1.159×10^{-3}	.751	.011	1.5 **
ATC(A)1	FSG	200	.355	.430	7.201	3.874×10^{-3}	.675	.036	5.3 **
ATC(A)2	BLK3A	221	.162	.188	0.935	5.752×10^{-1}	.169	.027	16.1
ATC(A)3	BLK3B	217	.046	.210	4.401	2.899×10^{-2}	.000	.252	. *
ATC(A)4	BLK5A	205	.153	.299	7.260	3.130×10^{-3}	.479	.121	25.2 **
ATC(A)5	BLK5B	204	.161	.191	1.087	5.468×10^{-1}	.295	.015	5.1
ATC(A)6	FAA	251	.492	.524	4.488	1.352×10^{-2}	.740	.013	1.7 *
ATC(B)1	FSG	284	.418	.426	0.888	4.852×10^{-1}	.749	.003	0.4
ATC(B)2	BLK2	349	.352	.373	1.739	1.172×10^{-1}	.646	.009	1.3
ATC(B)3	BLK3A	308	.138	.237	3.929	8.962×10^{-3}	.198	.160	80.9 **
ATC(B)4	BLK5A	295	.272	.372	7.488	1.181×10^{-4}	.454	.092	20.2 **
ATC(B)5	BLK5B	291	.226	.274	2.594	6.405×10^{-2}	.528	.035	6.7
ATC(B)6	FAA	285	.459	.474	1.801	1.752×10^{-1}	.717	.011	1.5

* $p < .05$. ** $p < .01$.

Table J-3

ECAT Factor Incremental Validities for all Navy Criteria

			Uncorrected Multiple R				Corrected Multiple R		
School	Criterion	Sample Size	ASVAB	ASVAB +ECAT	Percent Variance	Probability of $F_{3,N-8}$	ASVAB	Increase	Percent
AC1	FSG	72	.569	.584	2.559	6.527×10^{-1}	.820	.000	0.0
AC2	PERF	76	.228	.383	11.095	6.561×10^{-2}	.399	.146	36.7
AC3	FAA	76	.339	.411	6.465	2.317×10^{-1}	.523	.054	10.2
AE1	FSG	278	.475	.530	7.702	1.642×10^{-4}	.666	.025	3.8 **
AE2	SUM2	273	.387	.453	7.059	4.178×10^{-4}	.596	.025	4.2 **
AMS1	FSG	244	.581	.583	0.209	9.203×10^{-1}	.846	.000	0.0
AMS2	PERF	244	.355	.383	2.356	1.382×10^{-1}	.639	.011	1.7
AO1	FSG	234	.488	.499	1.428	3.601×10^{-1}	.716	.006	0.8
AO2	PRACTL	229	.308	.328	1.423	3.720×10^{-1}	.492	.011	2.2
AV1	FSG	544	.494	.512	2.505	4.082×10^{-3}	.804	.005	0.6 **
AV2	BSCAV	192	.493	.517	3.300	1.121×10^{-1}	.839	.004	0.5
AV3	ADVAV	192	.316	.326	0.703	7.311×10^{-1}	.690	.000	0.0
AV4	PERFORM	352	.345	.373	2.342	4.653×10^{-2}	.656	.015	2.3 *
EM1	FSG	797	.437	.439	0.214	6.392×10^{-1}	.684	.000	0.0
EM2	PHASE1	797	.451	.455	0.387	3.844×10^{-1}	.723	.000	0.0
EN1	FSG	750	.581	.585	0.600	2.174×10^{-1}	.764	.001	0.1
ET1	FSG	86	.439	.520	10.548	4.874×10^{-2}	.782	.040	5.1 *
ET2	FSG2	86	.465	.516	6.854	1.575×10^{-1}	.811	.029	3.6
ET3	PERF	86	.384	.434	5.084	2.733×10^{-1}	.676	.041	6.1
FC1	FSG	778	.475	.490	1.934	2.032×10^{-3}	.821	.005	0.6 **
FC2	RADAR	780	.339	.368	2.344	4.609×10^{-4}	.734	.012	1.6 **
GM1	FSG	420	.402	.415	1.236	1.669×10^{-1}	.727	.001	0.2
GM2	HALF1	420	.428	.448	2.256	2.671×10^{-2}	.761	.004	0.5 *
GM3	HALF2	397	.424	.428	0.441	6.340×10^{-1}	.726	.000	0.0
MM1	FSG	801	.391	.402	1.084	3.583×10^{-2}	.555	.005	0.9 *
OS1	FSG	713	.549	.567	2.973	1.234×10^{-4}	.798	.009	1.1 **
OS2	WRIT	815	.474	.481	0.864	7.373×10^{-2}	.756	.003	0.4
OS3	PERF	815	.504	.548	6.752	2.060×10^{-11}	.782	.027	3.5 **
RM1	FSG	277	.508	.533	3.646	2.178×10^{-2}	.767	.011	1.4 *
RM2	PHASE3	277	.367	.388	1.863	1.736×10^{-1}	.677	.004	0.6

* $p < .05$. ** $p < .01$.

Table J-4

Incremental Validities from Adding one ECAT Factor to Four ASVAB Factors All Significant Criteria from Full Model

School	Criterion	Memory	Psychomotor	Space
11H(A)2	EVT1TO	.010*	.026**	.028**
11H(A)3	EVT2TO	.008	.033**	.022*
11H(A)4	EVT3TO	.010*	.025**	.016**
11H(A)5	EVTSUM	.012*	.034**	.027**
11H(A)6	TO_1	.000	.055**	.003
11H(B)2	EVT1TO	.029**	.090**	.036**
11H(B)3	EVT2TO	.035**	.076**	.032**
11H(B)4	EVT3TO	.000	.032*	.000
11H(B)5	EVTSUM	.021**	.086**	.023**
11H(B)6	TO_1	.063	.098**	.000
11H(B)7	TO_2	.000	.167**	.049**
11H(B)8	TO_3	.000	.205**	.063*
11H(B)9	ITVTOW	.000	.178**	.039**
13F1	FSG	.018**	.007**	.028**
13F2	MPRAD	.024**	.006**	.045**
13F3	FIRING	.011**	.005**	.009**
APS1	FSG	.009**	.000	.006**
APS2	ZHRS	.023**	.000	.000
APS3	AFPT70	.051**	.015*	.034**
ATC1	FSG	.012**	.006*	.013**
ATC3	BLK3A	.050*	.060**	.021
ATC4	BLK3B	.270**	.000	.122
ATC5	BLK5A	.067**	.056**	.088**
ATC7	FAA	.008**	.003	.012**
ATC(A)1	FSG	.031**	.021**	.018**
ATC(A)3	BLK3B	.270**	.000	.122
ATC(A)4	BLK5A	.089*	.047*	.120**
ATC(A)6	FAA	.011**	.005*	.012**
ATC(B)3	BLK3A	.134*	.089*	.030
ATC(B)4	BLK5A	.060**	.053**	.078**
AC2	PERF	.150*	.019	.142
AE1	FSG	.024**	.003*	.022**
AE2	SUM2	.024**	.000	.013**
AV1	FSG	.005**	.001	.004**
AV4	PERFORM	.009	.014*	.011*
ET1	FSG	.024	.022*	.038*
FC1	FSG	.000	.000	.003**
FC2	RADAR	.002*	.004	.000
GM2	HALF1	.000	.001	.005**
MM1	FSG	.000	.000	.006**
OS1	FSG	.007**	.000	.008**
OS3	PERF	.020**	.008**	.025**
RM1	FSG	.005*	.001	.004

* p < .05. ** p < .01.

Table J-5

Uncorrected Factor Validities for all Army Criteria

School	Criterion	N	ASVAB Factor				ECAT Factor		
			Verbal	Math	Tech	Clerical	Space	Memory	Psychomotor
11H(A)1	TOALL	554	.094	.167	.149	.105	.173	.165	-.058
11H(A)2	EVT1TO	556	.202	.199	.258	.048	.268	.180	-.224
11H(A)3	EVT2TO	555	.126	.156	.162	.075	.197	.146	-.183
11H(A)4	EVT3TO	550	.227	.202	.219	.054	.234	.177	-.209
11H(A)5	EVTSUM	546	.214	.210	.256	.060	.274	.194	-.242
11H(A)6	TO_1	542	.128	.151	.086	.132	.138	.107	-.188
11H(B)1	TOALL	320	.229	.104	.142	.106	.155	.146	-.111
11H(B)2	EVT1TO	320	.211	.188	.201	.115	.278	.237	-.326
11H(B)3	EVT2TO	319	.250	.194	.178	.205	.278	.262	-.335
11H(B)4	EVT3TO	319	.103	.138	.161	.082	.103	.067	-.181
11H(B)5	EVTSUM	316	.244	.221	.224	.174	.288	.251	-.361
11H(B)6	TO_1	319	.002	.033	.028	-.058	.091	-.061	-.165
11H(B)7	TO_2	320	.000	-.045	.058	-.104	.099	.019	-.230
11H(B)8	TO_3	319	.058	.043	.050	.076	.143	.076	-.250
11H(B)9	ITVTOW	318	.008	.004	.047	-.067	.125	-.008	-.244
13F1	FSG	821	.388	.434	.379	.263	.496	.401	-.308
13F2	MPRAD	821	.369	.430	.368	.234	.525	.407	-.294
13F3	FIRING	821	.318	.353	.292	.217	.329	.298	-.236
19K1	COMM	1158	.010	.004	-.019	.025	-.017	-.012	.013
19K2	WEAPON	1325	.097	.153	.098	.091	.103	.102	-.078
19K3	LANDNAV	1192	.063	.147	.079	.100	.103	.109	-.098
19K4	LOADER	1313	.038	.014	.039	.012	.022	.019	-.026
19K5	MAINT	1329	.043	.082	.053	.030	.048	.050	-.035
19K6	NBC	1313	.068	.086	.046	.093	.043	.037	-.076
19K7	AVERAGE	1106	.106	.169	.101	.139	.135	.126	-.106

Table J-6

Uncorrected Factor Validities for all Air Force Criteria

School	Criterion	N	ASVAB Factor Verbal	Math	Tech	Clerical	ECAT Factor Space	Memory	Psychomotor
APS1	FSG	446	.361	.472	.316	.163	.341	.329	-.095
APS2	ZHRS	446	-.239	-.327	-.102	-.244	-.176	-.306	.025
APS3	AFPT70	432	.113	.090	-.097	.206	.149	.226	.131
ATC1	FSG	484	.311	.313	.301	.072	.320	.223	-.230
ATC2	BLK2	349	.234	.289	.297	-.001	.265	.172	-.246
ATC3	BLK3A	529	.083	.123	.056	.028	.110	.138	-.138
ATC4	BLK3B	217	-.044	-.029	-.018	-.001	.076	.178	-.030
ATC5	BLK5A	500	.044	.197	.086	.067	.287	.231	-.233
ATC6	BLK5B	495	.110	.140	.022	.145	.115	.144	-.101
ATC7	FAA	536	.401	.397	.349	.085	.380	.246	-.223
ATC(A)1	FSG	200	.242	.311	.251	.120	.340	.292	-.305
ATC(A)2	BLK3A	221	.117	.129	-.006	.064	.102	.086	-.090
ATC(A)3	BLK3B	217	-.044	-.029	-.018	-.001	.076	.178	-.030
ATC(A)4	BLK5A	205	.021	.102	.109	.023	.282	.185	-.199
ATC(A)5	BLK5B	204	.029	.089	-.038	.148	.101	.082	-.074
ATC(A)6	FAA	251	.355	.420	.384	.049	.405	.295	-.298
ATC(B)1	FSG	284	.350	.303	.340	.006	.286	.160	-.181
ATC(B)2	BLK2	349	.234	.289	.297	-.001	.265	.172	-.246
ATC(B)3	BLK3A	308	.058	.119	.105	-.000	.120	.182	-.175
ATC(B)4	BLK5A	295	.061	.260	.073	.099	.297	.266	-.254
ATC(B)5	BLK5B	291	.171	.177	.065	.143	.126	.193	-.121
ATC(B)6	FAA	285	.391	.347	.342	-.030	.257	.182	-.236

Table J-7

Uncorrected Factor Validities for all Navy Criteria

			ASVAB Factor				ECAT Factor		
School	Criterion	N	Verbal	Math	Tech	Clerical	Space	Memory	Psychomotor
AC1	FSG	72	.340	.538	.381	.212	.344	.342	-.192
AC2	PERF	76	-.051	.054	-.045	.209	.205	.285	-.063
AC3	FAA	76	.242	.261	.295	.118	.248	.105	-.049
AE1	FSG	278	.385	.354	.412	.130	.418	.373	-.254
AE2	SUM2	273	.244	.302	.346	.069	.336	.334	-.139
AMS1	FSG	244	.450	.441	.364	.323	.239	.148	-.085
AMS2	PERF	244	.155	.209	.185	.265	.233	.156	-.106
AO1	FSG	234	.262	.439	.245	.308	.284	.154	-.132
AO2	PRACTL	229	.114	.225	.076	.282	.207	.168	-.093
AV1	FSG	544	.174	.450	.235	.199	.349	.285	-.180
AV2	BSCAV	192	.249	.458	.156	.110	.374	.287	-.157
AV3	ADVAV	192	.204	.285	.056	.162	.170	.118	-.132
AV4	PERFORM	352	.015	.228	.243	.044	.235	.181	-.186
EM1	FSG	797	.248	.388	.302	.167	.264	.208	-.126
EM2	PHASE1	797	.236	.422	.283	.145	.271	.211	-.110
EN1	FSG	750	.434	.443	.500	.170	.393	.268	-.211
ET1	FSG	86	.160	.284	.291	.092	.412	.260	-.349
ET2	FSG2	86	.166	.389	.113	.291	.355	.305	-.228
ET3	PERF	86	.026	.314	-.078	.323	.188	.232	-.198
FC1	FSG	778	.260	.362	.277	.211	.273	.120	-.154
FC2	RADAR	780	.204	.148	.264	.132	.138	-.011	-.133
GM1	FSG	420	.272	.271	.244	.142	.279	.204	-.220
GM2	HALF1	420	.247	.344	.203	.189	.327	.233	-.234
GM3	HALF2	397	.280	.187	.339	.111	.242	.140	-.168
MM1	FSG	801	.266	.288	.335	.153	.295	.182	-.159
OS1	FSG	713	.305	.507	.368	.212	.453	.375	-.252
OS2	WRIT	815	.311	.437	.335	.127	.353	.301	-.199
OS3	PERF	815	.212	.448	.341	.208	.466	.397	-.294
RM1	FSG	277	.421	.445	.324	.174	.334	.290	-.099
RM2	PHASE3	277	.299	.330	.257	.069	.281	.231	-.114

Table J-8

Range-Corrected Factor Validities for all Army Criteria

School	Criterion	N	ASVAB Factor Verbal	Math	Tech	Clerical	ECAT Factor Space	Memory	Psychomotor
11H(A)1	TOALL	554	.158	.222	.200	.142	.220	.198	-.098
11H(A)2	EVT1TO	556	.291	.281	.360	.109	.356	.257	-.297
11H(A)3	EVT2TO	555	.194	.203	.236	.102	.254	.191	-.236
11H(A)4	EVT3TO	550	.307	.283	.300	.117	.313	.254	-.268
11H(A)5	EVTSUM	546	.303	.290	.352	.119	.357	.268	-.313
11H(A)6	TO_1	542	.180	.195	.156	.179	.190	.151	-.242
11H(B)1	TOALL	320	.321	.226	.233	.224	.244	.231	-.170
11H(B)2	EVT1TO	320	.260	.255	.281	.168	.326	.282	-.363
11H(B)3	EVT2TO	319	.348	.312	.282	.311	.365	.354	-.394
11H(B)4	EVT3TO	319	.149	.194	.217	.140	.163	.112	-.236
11H(B)5	EVTSUM	316	.323	.319	.323	.261	.365	.325	-.417
11H(B)6	TO_1	319	-.024	.005	.035	-.103	.038	-.107	-.147
11H(B)7	TO_2	320	-.018	-.043	.072	-.112	.074	-.010	-.213
11H(B)8	TO_3	319	.074	.070	.101	.074	.141	.083	-.258
11H(B)9	ITVTOW	318	-.021	-.013	.060	-.104	.077	-.051	-.222
13F1	FSG	821	.586	.638	.543	.477	.638	.548	-.409
13F2	MPRAD	821	.562	.627	.531	.450	.654	.548	-.397
13F3	FIRING	821	.498	.537	.443	.405	.489	.445	-.334
19K1	COMM	1158	.017	.008	-.011	.026	-.014	-.007	.020
19K2	WEAPON	1325	.136	.185	.140	.135	.138	.134	-.105
19K3	LANDNAV	1192	.101	.178	.124	.133	.140	.134	-.136
19K4	LOADER	1313	.053	.037	.054	.032	.041	.036	-.036
19K5	MAINT	1329	.071	.101	.075	.061	.069	.072	-.052
19K6	NBC	1313	.106	.125	.084	.132	.080	.070	-.097
19K7	AVERAGE	1106	.169	.224	.161	.200	.188	.172	-.147

Table J-9

Range-Corrected Factor Validities for all Air Force Criteria

			ASVAB Factor				ECAT Factor		
School	Criterion	N	Verbal	Math	Tech	Clerical	Space	Memory	Psychomotor
APS1	FSG	446	.681	.730	.559	.495	.626	.575	-.320
APS2	ZHRS	446	-.534	-.601	-.349	-.503	-.461	-.531	.235
APS3	AFPT70	432	.268	.305	.093	.337	.303	.359	-.014
ATC1	FSG	484	.619	.584	.531	.383	.561	.487	-.381
ATC2	BLK2	349	.511	.492	.498	.255	.472	.395	-.350
ATC3	BLK3A	529	.174	.200	.113	.141	.199	.227	-.203
ATC4	BLK3B	217	.075	.099	.055	.106	.168	.266	-.123
ATC5	BLK5A	500	.247	.379	.234	.281	.443	.414	-.341
ATC6	BLK5B	495	.292	.318	.164	.306	.280	.311	-.226
ATC7	FAA	536	.707	.667	.588	.436	.626	.533	-.399
ATC(A)1	FSG	200	.534	.581	.462	.430	.556	.538	-.426
ATC(A)2	BLK3A	221	.103	.159	.016	.136	.132	.140	-.163
ATC(A)3	BLK3B	217	.075	.099	.055	.106	.168	.266	-.123
ATC(A)4	BLK5A	205	.239	.323	.279	.250	.434	.391	-.317
ATC(A)5	BLK5B	204	.146	.213	.061	.258	.204	.214	-.193
ATC(A)6	FAA	251	.675	.672	.601	.415	.637	.549	-.423
ATC(B)1	FSG	284	.666	.568	.581	.324	.538	.447	-.351
ATC(B)2	BLK2	349	.511	.492	.498	.255	.472	.395	-.350
ATC(B)3	BLK3A	308	.122	.158	.135	.060	.187	.239	-.203
ATC(B)4	BLK5A	295	.246	.415	.197	.313	.456	.439	-.349
ATC(B)5	BLK5B	291	.415	.405	.260	.338	.364	.405	-.270
ATC(B)6	FAA	285	.686	.616	.577	.344	.561	.501	-.407

Table J-10

Range-Corrected Factor Validities for all Navy Criteria

			ASVAB Factor				ECAT Factor		
School	Criterion	N	Verbal	Math	Tech	Clerical	Space	Memory	Psychomotor
AC1	FSG	72	.611	.805	.511	.570	.620	.569	-.309
AC2	PERF	76	.128	.319	.030	.328	.391	.451	-.227
AC3	FAA	76	.490	.510	.438	.367	.414	.250	-.075
AE1	FSG	278	.564	.563	.556	.364	.587	.516	-.371
AE2	SUM2	273	.423	.497	.479	.286	.497	.453	-.256
AMS1	FSG	244	.708	.707	.705	.480	.618	.507	-.403
AMS2	PERF	244	.401	.451	.483	.373	.485	.397	-.328
AO1	FSG	234	.557	.657	.488	.477	.551	.428	-.387
AO2	PRACTL	229	.339	.391	.225	.401	.373	.338	-.246
AV1	FSG	544	.620	.763	.600	.470	.652	.568	-.405
AV2	BSCAV	192	.693	.789	.616	.453	.680	.580	-.395
AV3	ADVAV	192	.600	.618	.451	.436	.484	.411	-.347
AV4	PERFORM	352	.316	.443	.478	.178	.457	.361	-.352
EM1	FSG	797	.532	.641	.503	.415	.524	.439	-.311
EM2	PHASE1	797	.531	.668	.493	.407	.539	.450	-.307
EN1	FSG	750	.610	.628	.655	.374	.569	.430	-.372
ET1	FSG	86	.615	.699	.642	.444	.734	.616	-.532
ET2	FSG2	86	.651	.767	.577	.592	.738	.661	-.506
ET3	PERF	86	.489	.631	.394	.526	.574	.519	-.506
FC1	FSG	778	.688	.750	.653	.478	.651	.495	-.400
FC2	RADAR	780	.573	.539	.583	.357	.491	.324	-.371
GM1	FSG	420	.625	.651	.580	.413	.573	.466	-.379
GM2	HALF1	420	.621	.697	.568	.452	.610	.493	-.382
GM3	HALF2	397	.611	.597	.615	.379	.542	.419	-.338
MM1	FSG	801	.417	.459	.465	.294	.444	.332	-.279
OS1	FSG	713	.622	.734	.507	.565	.629	.567	-.369
OS2	WRIT	815	.589	.664	.484	.473	.546	.494	-.334
OS3	PERF	815	.523	.669	.479	.522	.631	.571	-.409
RM1	FSG	277	.652	.663	.504	.509	.565	.518	-.271
RM2	PHASE3	277	.509	.534	.431	.356	.480	.413	-.255

Appendix K

SAS Program for Stepwise Meta-Analysis

```
OPTIONS LS=79 MPRINT DQUOTE ;
/* PROGRAMS TO DO STEPWISE META-ANALYSIS;
   LOW-LEVEL ROUTINES APPEAR FIRST. */

%MACRO NUMLIST(LIST); /* RETURNS THE NUMBER OF ELEMENTS OF LIST */
   %LOCAL I;
   %LET I = 1;
   %DO %WHILE( %SCAN(&LIST,&I) NE);
       %LET I = %EVAL(&I + 1);
    %END;
   %EVAL(&I - 1)
%MEND NUMLIST;

 %MACRO REMOVE(J,LIST,N); /* REMOVES THE JTH MEMBER OF THE LIST */
     %LOCAL M;            /* N = NUMBER OF ELEMENTS OF LIST     */
     %DO M= 1 %TO &N;
        %IF &M NE &J %THEN %SCAN(&LIST,&M);
     %END;
 %MEND REMOVE;

 %MACRO REMOVAL(OUTS,LIST); /* RETURNS LIST - OUTS */
     %LOCAL  M N V;
     %LET N = %NUMLIST(&LIST);
     %DO M= 1 %TO &N;
        %LET V = %SCAN(&LIST,&M);
        %IF %INDEX(&OUTS, &V) = 0 %THEN &V;
     %END;
 %MEND REMOVAL;

 %MACRO STEP(RATING); /* FOR A GIVEN SCHOOL, COMPUTES THE MULTIPLE R
                         FROM ADDING OR DELETING EACH PREDICTOR */
  %IF &NVL2 NE 0 %THEN %DO; /* SKIP IF NO MORE VARIABLES */
    DATA TEMP;SET LAWCOR.N&RATING;IF GROUP=3; /* GET LAWLEY-CORRECTED */
    DATA _NULL_;SET TEMP END=LAST;            /* CORRELATIONS FROM DISK*/
      IF LAST THEN CALL SYMPUT('DEP',_NAME_);
    DATA _NULL_; SET ALL.RELX;  /* RETRIEVE RELIABILITY FROM DISK */
      IF INDEX(SCHOOL,TRIM(LEFT("&RATING"))) > 0  THEN DO;
         REL = RELINDX**2;
         CALL SYMPUT('REL',REL);
      END;

    PROC RSQUARE DATA=TEMP(TYPE=CORR) NOPRINT  ADJRSQ OUTEST = &RATING;
         %DO M = 1 %TO &NVL2; /* SET UP A MODEL FOR EACH REMAINING VAR */
           %LET V = %SCAN(&VL2,&M);
           %IF &DELETION %THEN  %LET VLM = %REMOVE(&M,&VL2,&NVL2);
                        %ELSE  %LET VLM = &VL1 &V;
           &V : MODEL &DEP = &LIST1 &VLM / INCLUDE=&NIV STOP=&NIV1 ;
         %END;
    DATA &RATING; SET &RATING; _ADJRSQ_ = _ADJRSQ_/&REL;
  %END; RUN;
%MEND STEP;
```

```
%MACRO METSTEP(RATINGS,LIST1,LIST2); /* THE MAIN META-ANALYSIS */
/* LIST1 = LIST OF VARIABLES THAT ALWAYS REMAIN IN REGRESSION */
/* LIST2 = LIST OF VARIABLES THAT ARE ADDED OR DELETED */
%LET NR = %NUMLIST(&RATINGS);
TITLE 'STEPWISE META-ANALYSIS FOR BEST MEAN WHERRY-SHRUNKEN R';
TITLE2 "&RATINGS";
TITLE3 'THE FOLLOWING PREDICTORS REMAIN IN REGRESSION AT ALL TIMES:';
TITLE4 "&LIST1";

/* VL1 = THAT PART OF LIST2 THAT IS IN REGRESSION DURING ACCRETION
         OR THAT HAS BEEN DELETED FROM LIST2 DURING DELETION */
/* VL2 = THAT PART OF LIST2 THAT IS NOT YET IN REGRESSION DURING THE
         ACCRETION PHASE, OR THAT REMAINS IN REGRESSION DURING THE
         DELETION PHASE */
%LET NLIST1 = %NUMLIST(&LIST1); %LET NLIST2 = %NUMLIST(&LIST2);
%DO DELETION = 0 %TO 1; /* ACCRETION PHASE FIRST, FOLLOWED BY DELETION*/
%LET VL1 = ;   %LET VL2  = &LIST2;
%LET NVL1 = 0; %LET NVL2 = &NLIST2;
%DO PR = 1 %TO &NLIST2; /* LOOP OVER CANDIDATE PREDICTORS */
     %IF &DELETION %THEN  %LET NIV = %EVAL(&NLIST1 + &NVL2 - 1);
                   %ELSE  %LET NIV = %EVAL(&NLIST1 + &NVL1 + 1);
     /* NIV = NUMBER OF PREDICTORS CURRENTLY IN REGRESSION */
     %LET NIV1 = %EVAL(&NIV + 1);
     %DO IR = 1 %TO &NR;
         %LET RATING = %SCAN(&RATINGS,&IR);
         %STEP(&RATING)
     %END;
     DATA BASE ;SET &RATINGS;
     PROC SORT DATA=BASE; BY _MODEL_;
DATA BASE;SET BASE; IF _ADJRSQ_ < 0 THEN _ADJRSQ_ = 0;
                    _ADJRSQ_ = SQRT(_ADJRSQ_);

 PROC MEANS DATA=BASE NOPRINT; VAR _ADJRSQ_; WEIGHT _EDF_; BY _MODEL_;
      OUTPUT OUT=MBASE MEAN=MEANRSQ;
DATA MAXMEAN ;SET MBASE END=LAST;
     RETAIN MAXR 0  BESTV;
     FORMAT NIV 4. ;
     IF MEANRSQ > MAXR THEN DO;
        MAXR = MEANRSQ;
        BESTV = _MODEL_;    END;
     IF LAST THEN  CALL SYMPUT('BESTV',BESTV); ELSE DELETE;
     NIV = SYMGET('NIV');
     DROP MEANRSQ _MODEL_;

 PROC APPEND BASE=MAXR&DELETION NEW=MAXMEAN;

 %LET VL1 = &VL1 &BESTV;
 %LET VL2 = %REMOVAL(&BESTV,&VL2);
 %LET NVL1 = %EVAL(&NVL1 + 1);
 %LET NVL2 = %EVAL(&NVL2 - 1);
%END; /* PR LOOP OVER PREDICTORS */
 PROC PRINT DATA= MAXR&DELETION; TITLE5 "MAXR&DELETION"; RUN;
%END; /* ACCRETION/DELETION LOOP */
 PROC SORT DATA=MAXR1; BY NIV;
 DATA MAXR1;SET MAXR1; RENAME MAXR=R_DEL BESTV = V_DEL;

 DATA MAXR;MERGE MAXR0 MAXR1; BY NIV;
      RENAME MAXR = R_ADD BESTV = V_ADD;
 PROC PRINT DATA=MAXR NOOBS; VAR NIV V_ADD R_ADD V_DEL R_DEL;
 TITLE5 'COMBINED ACCRETION AND DELETION RESULTS'; RUN;

DATA MAXR0;SET MAXMEAN; IF 0; /* RESET FOR FUTURE APPENDING */
DATA MAXR1;SET MAXR0;
```

```
 %MEND METSTEP;

%LET ASVAB = GS1 AR1 WK1 PC1 NO1 CS1 AS1 MK1 MC1 EI1  ;
%LET AFQT = AR1 WK1 PC1 MK1;
%LET NONAFQT = GS1 NO1 CS1 AS1 MC1 EI1;
%LET ECAT  = MCPCOR SMPDCOR IDPCOR AOPCOR T1MN T2MN SRPCOR ORPCOR TIDDT;
%LET NOMOTOR  = MCPCOR SMPDCOR IDPCOR AOPCOR  SRPCOR ORPCOR ;
%LET NOCOMP  =  AOPCOR  SRPCOR ORPCOR ;
   %LET TLST = A11H5 B11H5 A13F1;
   %LET FSGS = A11H5 B11H5 A13F1       APS1 ATC1 AC1 AE1 AMS1 AO1 AV1
               EM1 EN1 ET2 FC1 GM1 MM1 OS1 RM1;
   %LET BESTD = A11H6 B11H9 A13F3       APS3 ATCX4 ATCY4
                AC2 AE2 AMS2 AO2 AV4 EM2 EN1 ET3 FC2 GM3 MM1 OS3 RM2;
   %LET FSGS9=            A13F1        APS1 ATC1
          AC1 AE1 AMS1 AO1  AV1  ET2    OS1 ;
   %LET BESTD9 =            A13F3       APS3 ATCX4 ATCY4
                AC2 AE2 AMS2  AO2     AV4        ET3             OS3    ;
```

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